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DUTCHTOWN FAUNA OF SOUTHEASTERN MISSOURI

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ABSTRACT

The Dutchtown, a recently described Ordovician formation of southeastern Missouri lying within the Buffalo River group between the Everton or St. Peter and Joachim formations, contains a fauna whose exact age and equivalents are unknown. One species of bryozoan, three gastropods, two pelecypods, one ostracode, and five conodonts are described as new. For the last the new genera *Multioistodus* and *Archeognathus* are erected and referred to the class Pisces because of their bony structure.

In 1911 Ulrich (6) named the Buffalo River group of Missouri and Arkansas and included therein the Everton, St. Peter and Joachim formations. Later Dake (2) described the general relations of the Buffalo River group of Missouri, emphasizing especially the St. Peter sandstone, and in 1921 he (3) discussed in detail the problem of the St. Peter sandstone. From that time until his death Dake was very much interested in the stratigraphy of the Buffalo River group. In May, 1934, he received a grant from the Penrose Bequest of the Geological Society of America for a study of the relations of the Buffalo River group and the Simpson group. The writer at that time agreed to assist him with the paleontology involved. Work was immediately started but terminated abruptly with the sudden death of Doctor Dake in the late summer of that year. The writer, although fully aware that he was not as familiar with the general problem as his associate and consequently not as competent to deal with the entire problem, asked for and obtained permission to carry on the work as an attempt to salvage as much information as possible from the collections already made.

The Buffalo River group as originally defined by Ulrich (6) included the Joachim dolomite at the top, the St. Peter sandstone, and the Everton sandstone and dolomite. Recently McQueen (5, *a*) has described the Dutchtown formation, which lies unconformably between the Joachim and the St. Peter and Everton of Ulrich's section. The limestones and shales of the Dutchtown are the only rocks in the entire Buffalo River group that contain fossils in abundance. It was expected by Dr. Dake that some element of the Dutchtown fauna could be correlated not only with the lower part of the Simpson group but also with a part of the Stones River group of the Central Basin of Tennessee.

The loss of Dr. Dake's broad knowledge of the formations of Chazy age has necessitated the restriction of the original problem to the description of the fauna of the Dutchtown and its possible relations.

The author is indebted to Dr. Josiah Bridge of the U. S. Geological Survey for assistance and suggestions in the field work and identifications; to Professor C. E. Decker of the University of Oklahoma for the loan of collections of fossils from the Simpson group; to those members of the staff of the U. S. National Museum who have given freely of their time and knowledge; to Dr. E. B. Branson of the University of Missouri for his assistance with the conodonts; to the Missouri State Geological Survey for the many courtesies which they have shown during the course of the work; to his colleagues of the Department of Geology at the Missouri School of Mines and Metallurgy; and to the Geological Society of America for a grant of funds with which to carry on the work.

TYPICAL OUTCROPS OF DUTCHTOWN

The areal extent, thickness and lithologic character of the Dutchtown have for the most part been determined from the cuttings obtained from drilled wells. In the area where it is known to be the formation next below the soil cover, there are relatively few surface exposures. In the area where it should be present, east of the line of the upper boundary of the St. Peter-Everton, as indicated by McQueen (5, *b*), only two localities are of significance. The first is on the north side of State Highway 74 1.3 to 1.8 miles east of the village of Dutchtown, Cape Girardeau County, Missouri. The second is in the diversion channel of Sals Creek approximately one-half mile west of Ancell, Scott County, Missouri.

At the first place the two exposures significant as possible collecting areas are (1) the abandoned quarry on the farm of Arnold Geiser 1.3 miles east of Dutchtown (Missouri School of Mines No. 93.1) and (2) a small drain between two culverts on the north side of the highway just west of the point where the old road swings away to the north from the present highway, approximately 1.55 miles east of Dutchtown (Missouri School of Mines No. 93.21).

A detailed section measured by McQueen (5, *c*) at the Geiser quarry is given below.

Section at Geiser quarry

	Ft.	In.
Middle member:		
8. Limestone, dense, grayish-blue and brown lithographic, argillaceous; breaks with a conchoidal fracture and thin splintery edges. Weathers to a buff color. Contains thin buff partings of clay..	1	9
7. Limestone, light-bluish and brownish-gray, with one-half inch darker blue bands parallel to bedding; dense, lithographic, massive but weathers along the darker colored bands into thin beds 3 inches thick. Thin shale partings are common. Upper and lower parts of this bed are fossiliferous and contain crystalline calcite.....	1	8
6. Limestone, similar to that in bed no. 2; dense, best exposed in vertical face along joint plane, striking N. 43° W.; weathers along shaly partings into beds 2 inches to 12 inches thick.....	3	6
5. Limestone, buff, fissile, and shaly	0	1
4. Limestone, brown, lithographic, contains small flat gastropods...	0	9
3. Limestone, shaly as in no. 4....	0	2
2. Limestone, dark-blue to brown, dense to finely crystalline, and slightly granular in upper portion, occurs in one bed; gastropods and pelecypods are common. Limestone conglomerate of shingle type occurs near the base....	2	6
Lower member:		
1. Limestone, dark-blue to black, very nodular, weathers in 6-inch beds, with thin, dark-brown, shaly partings. Ostracodes are common in the limestone, and conodonts are present in the shale. Exhibits locally, a wavy-bedded, reeflike appearance. Calcite-encrusted partings, and calcite-lined vugs also noted. Asphalt occasionally noted in vugs.....	5	0
Total thickness exposed.....	15	5

Bed 2 of the above section has furnished the greater number of the macrofossils from this exposure. The bed is largely composed of gastropods of the genus *Lophospira*, along with pelecypods of the genus *Ischyrodonta* and numerous ostracodes. Conodonts are generally present throughout the shales of this section. The shales are very thin and decidedly calcareous; consequently great difficulties are encountered in obtaining complete specimens even under the proper conditions of preparation.

At the other neighboring exposure

(Missouri School of Mines no. 93.21, see measured section below), the beds are weathered more than those at the Geiser quarry and consequently yield complete conodonts more readily.

Section of lower middle Dutchtown in small drain 1.55 miles east of Dutchtown

	Ft.	In.
10. Limestone, crystalline, dark brownish-gray medium-bedded; contains cephalopods and cryptozoans	3	0
9. Clay, light greenish-yellow, very sticky; contains an abundance of free conodonts	0	3
8. Limestone, light bluish-gray, fine-grained; laminations of thin calcareous shales at the top	4	6
7. Limestone, light bluish-gray, fine-grained curvatures of cryptozoans throughout	0	8
6. Limestone, light bluish-gray, fine-grained irregularly bedded with varying thicknesses of shale laminations throughout	1	10
5. Covered	3	0
4. Shale, dark brownish-gray, very thinly bedded, calcareous; contains many deformed ostracodes	0	8
3. Limestone, dark grayish-brown dense; gives off fetid odor when struck with hammer; contains many ostracods	0	4
2. Shale, dark-brown, extremely thinly bedded, calcareous; contains many deformed ostracods	0	½
1. Limestone, dolomitic, light-gray with pinkish-brown mottles. The upper surface is covered with pebbles, usually pink or brown, of 1½ inches maximum diameter. Limestone shows sun cracks. Base not exposed	0	6
Total thickness exposed	14	9½

The locality along the diversion channel of Sals Creek one-half mile west of Ancell, Scott County, Missouri (Missouri School of Mines no. 101.1), is the most extensive series of exposures of the formation known. The largest linear exposure is in the walls of the channel, which have been cut from solid rock. It lies just upstream from where the county road and railroad cross the channel. Here the section is freshly exposed. The limestones are conspicuous. Many of the argillaceous beds have been eroded from between the limestones by the rush of high waters. Only in the very upper part of the exposed section is it possible to collect samples from which the microfauna can be successfully freed. The beds above the base of the middle Dutchtown contain more shale than those at the Geiser quarry. The greatest variety of megascopic forms obtained from the formation has come from this place, probably because the beds are more fully exposed there than elsewhere. Gastropods predominate there, as at every other known outcrop. Pelecypods are plentiful and cephalopods common. One very poorly preserved pygidium of a trilobite and a fairly complete maxillary of a conodont have been collected from the shales high in the section at the west end of the exposure.

THE DUTCHTOWN FAUNA

Unfortunately both the underlying St. Peter and the overlying Joachim are poor in megascopic fossils. No fossils have been recorded as definitely from the St. Peter in the state of Missouri. Recently Branson and Mehl (1, *a*) have described a very abundant and distinctive microfauna in the Joachim.

Fortunately the Dutchtown contains not only an excellent megascopic fauna but also a very distinctive microfauna. The few species here described represent those most numerous in the bulk of specimens collected. The megascopic fauna is predominantly molluscan. In numbers the gastropods predominate. The most abundant, distinctive, and easily recognized form in the entire assemblage is the new species *Lophospira dutchtownensis*, which is more inflated than the spe-

cies of *Lophospira* that occupy higher zones in the Ordovician. Fragments of a small low-spired unidentified gastropod are very abundant.

The pelecypods rank next to the gastropods in abundance. New species of *Ischyrodonta* and *Modiolopsis* are very distinct and especially abundant in the lower part of the middle Dutchtown.

Only one species of Bryozoa has been recognized, *Crepipora globulifera*, n. sp., which is fairly abundant and occurs at both the important localities.

Careful comparisons with both the identified and the described collections of the U. S. National Museum have failed to reveal specimens specifically the same as any of those herein described.

The microfauna of the Dutchtown is abundant in genera and species of conodonts and in specimens of ostracodes. The ostracodes are represented by at least two genera, one of which, *Isocholina*, is by far the most important. The species herein described, *I. variana*, is known throughout all exposures of the Dutchtown formation, both in the shales and in the limestones. Its characteristics are quite distinct, and it would have undoubtedly have figured or at least mentioned if it were in any of the already described Ordovician faunas.

The conodonts herein described are represented by two genera including five species. The three most abundant and easily recognized species herein described are *Multioistodus subdentatus*, *M. lateralis* and *M. tridens*. These relatively simple forms far outnumber the simple cones similar to those described from the Jefferson City formation by Branson and Mehl (1, *b*) and are more abundant than the more complicated species that they have described from the Joachim. Because a great number of the specimens retain a portion of the jaw to which they were attached and are decidedly fibrous yet are associated with a few forms that occur abundantly in the overlying Joachim, the entire assemblage from the Dutchtown seems to be younger than the true Harding fauna as described by Branson and Mehl, but older than that which they described from the overlying formations. The Dutchtown conodonts appear to be older than the assemblages obtained from the lower part of the Oil Creek formation of Oklahoma.

From each of the two important localities heretofore mentioned there has been obtained an outstanding specimen of a jaw. These are of a bone-like substance on which cones like conodont teeth are set in a single row. These two specimens support the theory that at least some conodonts are the teeth of ancient fishes rather than the jaws of annelids. It is the author's intention to study further these specimens and others which may be obtained from the same formation in order to obtain more information on this rather controversial subject.

Stratigraphically the Dutchtown lies within the Buffalo River group. Faunally it is new. The decided lack of brachiopods and trilobites diagnostic of either Chazyan or Beekmantown affinities makes it very difficult to place. At the same time, however, this condition suggests quite strongly that the Dutchtown fauna is a facies development, which may eventually be found at least in part elsewhere

SYSTEMATIC DESCRIPTIONS

Class BRYOZOA

Order CYCLOSTOMATA

Genus CREPIPORA Ulrich, 1882

CREPIPORA GLOBULIFERA

Cullison, n. sp.

Plate 29, figures 1–3

Zoarium globular, irregularly hemispherical to spherical, up to 4 cm. in diameter, surface evenly convex. Apertures direct, generally polygonal with no apparent regular arrangement, about 26 to 30 in one cm. There seems to be no specific grouping of the larger zoecia in maculae. Walls of the zoecia about three times as thick as diaphragms; structure ragged. Diaphragms thin, spaced somewhat less than their own

diameter apart, slightly cupped at the zoecial walls. Lunaria very inconspicuous. The external form and general lack of a definite internal structural pattern serve to differentiate this species.

Occurrence.—Lower part of the middle Dutchtown formation, Geiser quarry 1.3 miles east of Dutchtown, Cape Girardeau County, Missouri; and Sals Creek diversion channel 0.5 mile west of Ancell, Scott County, Missouri.

Syntypes.—Nos. 7100, 7102, 7103, paleontological collections, Missouri School of Mines and Metallurgy.

Class GASTROPODA

Order PECTINIBRANCHIATA

Genus LOPHOSPIRA Whitfield, 1886

LOPHOSPIRA BASICARINATA

Cullison, n. sp.

Plate 29, figures 7a, b

Height 15 to 20 mm.; apical angle 50° to 55°. Volutions four or five, subangular; last one slightly ventricose below, keeled and quadricarinate, the upper ones keeled and monocarinate, the lower three carinae being concealed by the suture, peripheral angle marked by a prominent subcentral keel somewhat square in cross section; upper carina broad and faint, removed about half the distance of the flat upper slope; lower carinae three in number, thin, becoming less prominent towards the umbilicus, equally spaced, separated from the keel by a narrow slightly concave surface and from the very small umbilicus by a relatively broad inflated surface. Surface marked by fine, sharp, subequal, somewhat grouped striae, curving backwards gently from the suture to the keel, passing over the upper carina without interruption, crossing the keel as vertical lines, then angling forward as a straight line across the slightly depressed area to the first carina, thence curving slightly backward across the carinae to the umbilicus.

This species resembles somewhat *Lophospira bicincta* but differs in its flattened upper surface, number of carinae, and general trend of the growth lines.

Occurrence.—Middle Dutchtown, Sals Creek diversion channel 0.5 mile west of Ancell, Scott County, Missouri.

Holotype.—No. 7104, paleontological collections, Missouri School of Mines and Metallurgy.

LOPHOSPIRA CORRUGATA

Cullison, n. sp.

Plate 29, figure 6

Height 25 to 30 mm.; apical angle 45° to 50°. Volutions five to six, subangular, last volution ventricose below, bears five broadly rounded carinae, one above and four below the broadly rounded, sub-central keel, which marks the peripheral angle. The upper volutions bear the prominent keel but few if any carinae; upper surface relatively plane; strong broadly rounded carina in the lower third of the distance from the keel to the suture. Lower surface bears four broadly rounded carinae, diminishing in strength and space-distance from the keel to the umbilicus; surface markings lacking on the holotype, which is an internal mould.

This species is characterized by the two relatively strong broadly rounded carinae equally spaced above and below the broadly rounded keel, and the broad carinae on the basal surface, all of which tend to give the specimen a corrugated appearance.

Occurrence.—Middle Dutchtown, Geiser quarry, 1.3 miles east of Dutchtown, Cape Girardeau County, Missouri; and Sals Creek diversion channel 0.5 mile west of Ancell, Scott County, Missouri.

Syntypes.—Nos. 7105 and 7106; paleontological collections, Missouri School of Mines and Metallurgy.

LOPHOSPIRA DUTCHTOWNENSIS

Cullison, n. sp.

Plate 29, figures 4, 5

Height 25 to 30 mm., apical angle 45° to 50°. Volutions five to six, ventricose,

with only faint suggestions of broad carinae above and below the angle, peripheral angle about central, marked by prominent rounded keel ending in a wide shallow apertural notch forming an angle of approximately 110°. Surface markings very fine irregularly spaced striae curving gently back from the suture to a point near the keel and then decidedly backwards to cross the keel at right angles, thence only slightly forward to turn immediately downward to the relatively small umbilicus.

This species is by far the most numerous of all the Dutchtown gastropods and is characterized by its generally smooth surface, especially as internal moulds.

Occurrence.—Middle Dutchtown, Geiser quarry, 1.3 miles east of Dutchtown, Cape Girardeau County, Missouri; and Sals Creek diversion channel 0.5 mile west of Ancell, Scott County, Missouri.

Types.—Holotype, 7107; paratype, 7108, paleontological collections, Missouri School of Mines and Metallurgy.

Class PELECYPODA

Order PRIONODESMACEA

Genus ISCHYRODONTA Ulrich, 1890

ISCHYRODONTA DAKEI

Cullison, n. sp.

Plate 29, figure 9

Shell medium to small, moderately convex, subquadrate to ovate, widest posteriorly. Cardinal margin arcuate approximately the length of shell. Anterior end very short, rounding uniformly into the convex basal margin; posterior end broadly rounded. Surface of the thick shell generally smooth, bearing few growth lines. Hinge plate thick, wide, and flat; cardinal teeth strong. Anterior muscular impression deep with rounded outline. Posterior scar so inconspicuous as to appear absent, only faintly preserved on excellent internal moulds. Internal moulds generally smooth and broad. No umbonal ridge or furrows especially evident. A very slight, broad, shallow depression arises dorsal to the

---

EXPLANATION OF PLATE 29

FIGS. *1–3—Crepipora globulifera* Cullison, n. sp. *1*, Profile view of syntype ×1.3; *2*, tangential section of syntype ×10; *3*, longitudinal section of syntype ×10. (p. 222)

4, 5—Lophospira dutchtownensis Cullison, n. sp. *4*, Profile view of syntype ×1; *5*, profile view of paratype, an internal mold, ×1. (p. 223)

6—Lophospira corrugata Cullison, n. sp. Profile view of holotype, an internal mould, ×1. (p. 223)

7a, b—Lophospira basicarinata Cullison, n. sp. ×1. *a*, Profile view of holotype, an internal mold; *b*, basal view of holotype. (p. 223)

8—Modiolopsis convexa Cullison, n. sp. Right valve of syntype, ×2. (p. 225)

9—Ischyrodonta dakei Cullison, n. sp. Internal mold of right valve of syntype, ×1.3. (p. 224)

10–12—Isochilina variana Cullison, n. sp. *10*, Right valve of large syntype, ×1.3; *11*, left valve of small syntype, ×3.3; *12*, basal view of a left valve of syntype showing line of contact, ×1.3. (p. 225)

13a, b—Multioistodus subdentatus Cullison, n. sp., ×12. *a*, Right lateral view of syntype; *b*, left lateral view of syntype. (p. 226)

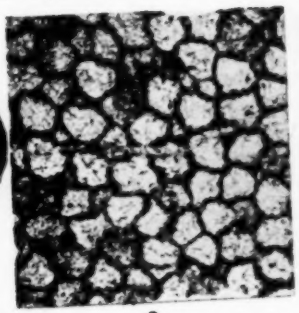
14—Multioistodus lateralis Cullison, n. sp. Holotype, ×14. (p. 226)

15a, b—Multioistodus tridens Cullison, n. sp. Syntype. *a*, Lateral view showing subcentral denticle, one lateral denticle broken off, and the other concealed, ×12; *b*, lateral view showing subcentral and lateral denticles, ×20. (p. 227)

16a, b—Archeognathus primus Cullison, n. sp. Holotype, ×3.3. *a*, Lateral view showing outer surface of the jaw; *b*, lateral view showing inner surface of the jaw. The entire specimen is supported by a cellulose film within a ring of the original matrix. (p. 227)

17—Archeognathus? carinatus Cullison, n. sp. Holotype, ×4. Fragments known to have at one time made up one jaw. (p. 228)

1.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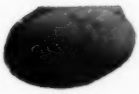
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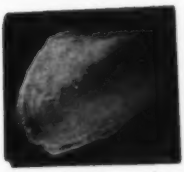
13a.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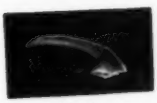
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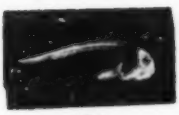
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16a.

12.

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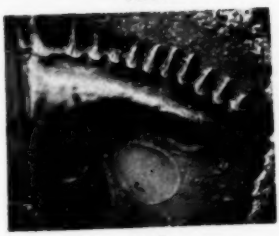
16b.

17.

Cullison, Ordovician Fossils

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anterior muscle scar, extends a short distance in a postbasal direction, and disappears on the broad surface. Greatest length of internal mould approximately 20 mm.; greatest height of internal mould approximately 15 mm.; convexity of internal mould approximately 10 mm.

This species differs from *I. truncata* in its lack of an umbonal ridge, its lesser convexity and broadly rounded posterior margin.

Occurrence.—Lower Middle Dutchtown, Geiser quarry, 1.3 miles east of Dutchtown, Cape Girardeau County, Missouri.

Holotype.—No. 7099, paleontological collections of the Missouri School of Mines and Metallurgy.

Genus MODIOLOPSIS Hall, 1847

MODIOLOPSIS CONVEXA
Cullison, n. sp.
Plate 29, figure 8

Internal mold small, strongly biconvex, obliquely elongate, greatest width at posterior end. Cardinal margin straight, length slightly less than greatest length of shell. Anterior end very short, rounded into the straight ventral margin. Posterior margin sharply rounded ventrally, broadly rounded dorsally into the posterior end of the dorsal margin. Surface of relatively thin shell generally smooth except for faint growth lines. Beaks prominent, anterior, extending slightly beyond dorsal margin of internal mould and curving over the slightly concave cardinal surface. Umbonal ridge strong, broad, extending towards the posterior ventral margin, where it disappears. Anterior and adjacent to the ridge, the surface is flat to broadly concave as the ventral margin is approached. Greatest convexity central. Cardinal teeth lacking.

Greatest length 10 mm.; greatest height (posterior) 7 mm.; greatest convexity (of right valve) 3 mm.; distance from posterior end of dorsal margin to antero-ventral margin 8 mm.

This species is characterized by its general outline, small size, prominently pointed umbos and central convexity.

Occurrence.—Lower Middle Dutchtown, Geiser quarry, 1.3 miles east of Dutchtown, Cape Girardeau County, Missouri; and Sals Creek diversion channel, 0.5 mile west of Ancell, Scott County, Missouri.

Types.—Holotype, 7109; paratype, 7110, paleontological collections of the Missouri School of Mines and Metallurgy.

Subclass EUCRUSTACEA

Superorder OSTRACODA

Genus ISOCHILINA Jones, 1858

ISOCHILINA VARIANA
Cullison, n. sp.
Plate 29, figures 10–12

Carapace small to medium, in lateral view obliquely sub-ovate; length, measured slightly dorsal to the center, barely less than twice the greatest height measured at posterior end of hinge line; biconvex, greatest convexity central. Hinge straight, extending anteriorly and posteriorly beyond curvature of valves to form a border, the right valve curving slightly dorsally to barely overlap that of the left valve. Valves slightly unequal, the right being the larger, overlapping very slightly the left internally throughout a short area on the ventral margin; ventral contact marked by a slightly raised line on the left valve; both valves bearing fairly wide borders at the anterior and posterior dorsal margins, which narrow rapidly and disappear at the mid-height of each end. Surface of valves generally smooth excepting the slightly lobed area near the pit and sulcus, marked in larger forms by irregularly distributed pores most abundant ventrally. Median sulcus broad at the hinge, narrowing rapidly to pit. Pit reticulated on internal moulds and produced dorsally as a small narrow lobe to form a narrow shallow short posterior sulcus. Eye spot prominent. Internal molds of the larger specimens of this form usually

show reticulations radiating from the pit to the anterior, posterior and ventral margins. Greatest length, 7 mm. Greatest height, 4 mm. Greatest thickness, 3.5 mm.

Occurrence.—Present throughout the Dutchtown at all listed exposures.

Syntypes.—Nos. 7111, 7112, 7113, paleontological collection of the Missouri School of Mines and Metallurgy.

Phylum VERTEBRATA

Class PISCES

Genus MULTIOISTODUS

Cullison, n. gen.

Base lachryforme to subtriangular, narrows anteriorly, broadens posteriorly, deepest about center. The cusp is most prominent, usually bladelike to subtriangular in cross section, bearing one or more prominent carinae. The denticles, usually bicarinate, one or more in number, are outgrowths from the base of the cusp, rather than from the area of the basal plane. This genus is established to include those species of a fibrous character that seem to be transitional between the simple bases and cusps of the genus *Oistodus* and the more complex dental units that have the denticles and cusp arising directly from the base,

Genotype.—Multioistodus subdentatus Cullison, n. sp.

MULTIOISTODUS SUBDENTATUS

Cullison, n. sp.

Plate 29, figures 13a, b

Base slightly flaring, lachryforme in general outline, anterior end acute, posterior subacute to obtuse. Usually slightly excavated, occasionally filled with jaw material. Cusp or blade meeting base at an angle of approximately 45° but soon flattening out towards its tip to lie parallel to the basal plane or even slightly depressed; terminus sharp, outside surface and anterior edge convex, inside surface flattened and bounded orally by a carina, which extends the full length of the cusp, forming a buttress anteriorly across the base on the oral side. The aboral posterior edge marked by a central carina extending from the tip of the cusp to the point just above the posterior end of the base, where a small, compressed, smooth denticle rises.

The denticle is short, stout and smooth and usually lies in the plane of the cusp and points in the same direction. This small denticle arising from the posterior aboral edge of the cusp is characteristic of the species and represents the minimum of complexity in the genus.

Occurrence.—Eleven feet above base of middle Dutchtown, 1.55 miles east of Dutchtown, Missouri.

Syntypes.—Nos. 7114 and 7115, paleontological collections of the Missouri School of Mines and Metallurgy.

MULTIOISTODUS LATERALIS

Cullison, n. sp.

Plate 29, figure 14

Base slightly flared, subtriangular in cross section, with apex of triangle anterior and the base of the triangle posterior; slightly excavated, usually filled with material from the jaw. Cusp most prominent of all denticles, gently curving posteriorly and orally from the base, the terminal half roughly parallel to the basal plane, acuminate. In cross section, outer surface a smooth convex curve from the inner oral edge to the outer aboral edge, aboral surface concave, inner surface concave. The inner oral edge marked by a carina, which extends from across the base to the tip. The inner and outer aboral edges marked by carinae extending from near the tip longitudinally along the oral and the aboral margins of the two short laterally compressed denticles, which rise from both sides of main cusp just above the base and across the slightly flaring base. The projection of the main cusp usually bisects the angle between the denticles, but in a few specimens has been observed directly oral to the outer denticle. It is intended to include such reasonable variations within this species.

Occurrence.—Eleven feet above the

base of the Middle Dutchtown, 1.55 miles east of Dutchtown, Missouri.

Holotype.—No. 7166, paleontological collections, Missouri School of Mines and Metallurgy.

Multioistodus tridens
Cullison, n. sp.
Plate 29, figures 15a, b

Base roughly triangular to rhombic, slightly flared in plan view, acute posteriorly, broadly obtuse laterally and anteriorly, usually filled with jaw material. Cusp most prominent, moderately to sharply curved into basal plane, terminally parallel to basal plane, acuminate, roughly triangular in cross section, surface divided into three areas by three sharp carinae; aboral surface broadly rounded, bounded on each side by a lateral carina extending from the base longitudinally across the lateral denticles, as in *M. lateralis*, and thence to the tip. The aboral surface and lateral surfaces are divided aborally by a central carina extending from the base longitudinally across a short denticle to the tip.

This species is erected to contain those specimens which seem to be a combination of species *M. subdentatus* and *M. lateralis*. It is characterized by having three small denticles, arising laterally and posteriorly from the cusp just above the base.

Occurrence.—Eleven feet above the base of the middle Dutchtown, 1.55 miles east of Dutchtown, Missouri.

Syntypes.—Nos 7117 and 7118, paleontological collections, Missouri School of Mines and Metallurgy.

Genus Archeognathus
Cullison, n. gen.

Jaws composed of a long and short bar joining at an angle. The longer bar bearing on its oral margin a single row of simple coneshaped teeth longitudinally grooved at the base.

Genotype.—Archeognathus primus Cullison, n. sp.

Archeognathus primus
Cullison, n. sp.
Plate 29, figures 16a, b

For the purpose of description, the specimen is oriented as the upper left jaw.

Jaw harpoonhaped, composed of two bars, the longer tapering posteriorly to a sharply rounded point and supposed to taper slightly a short distance anteriorly to a bluntly rounded point; observed length 7.1 mm.; length of complete specimen probably 8.5 mm.; curves orally at both extremities; maximum thickness and height at point of junction with the short bar; transverse section generally biconvex with sharpest edge at the base, which bears the teeth. Shorter bar broad, spatulate in outline, extremity broadly rounded; length 5.4 mm.; inclined ventro-anteriorly; joins long bar at an angle of 60° anterior to center; transverse section plano-convex with the convex side oral; bears no teeth. Teeth stout, simple cones of unequal size, broadly flared and longitudinally grooved at the base so as to clasp the jaw; suggestions of a carina from base to tip anteriorly and posteriorly; curved gently orally towards the point; color in reflected light, black; in transmitted light, dark amber; fibrous in structure. The teeth show the effects of corrosion at the tip. Ridges run longitudinally on the oral surface of the base of each tooth. These ridges are not present on the aboral surfaces of the teeth and may be due to etching by the acid used in freeing the specimen.

In general appearance the teeth resemble *Erismodus abbreviatus* Branson and Mehl (1, *c*) from the Harding sandstone of Colorado.

The aboral surface of the jaw is bluish white, like that of the fish plates described by Kirk (4) from the Harding sandstone of Colorado, and seems to be of the same composition.

Occurrence.—About six feet above the base of the middle Dutchtown at the west end of the Sals Creek diversion channel 0.5 mile west of Ancel, Scott County, Missouri.

Holotype.—No. 7119, paleontological collection, Missouri School of Mines and Metallurgy.

ARCHEOGNATHUS? CARINATUS
Cullison, n. sp.
Plate 29, figure 17

This species is based on fragments all known to have come from the same jaw. The jaw is decidedly biconvex in cross section; there is no high, narrow ridge on which the teeth are situated as in *A. primus*, but the oral edge is rounded. The fragment at the junction of the bars would suggest the same general relationship as the genotype. The ten teeth are similar to those of *A. primus* in color, composition and structure, but differ by having very sharp anterior and posterior carinae, which are straight from base to tip or twist about the tooth through an angle of 90°. The tips of the teeth are blunt and show wear.

Occurrence.—Base of the middle Dutchtown, Geiser quarry, 1.3 miles east of Dutchtown, Cape Girardeau County, Missouri.

Holotype.—No. 7120, paleontological collection, Missouri School of Mines and Metallurgy.

REFERENCES

1. BRANSON, E. B., and MEHL, M. G., Conodont studies: *Missouri Univ., Studies*, vol. 8; *a*, pp. 77–100, pls. 5–7; *b*, pp. 53–64, pl. 4, 1933. *c*, p. 25, pl. 1.
2. DAKE, C. L., The sand and gravel resources of Missouri: *Missouri Bur. Geology and Mines*, 2nd ser., vol. 15, pp. 101–130, 1918.
3. ———, Problem of the St. Peter sandstone: *Missouri Univ., School of Mines and Met., Bull., Tech. Ser.*, vol. 6, no. 1, pp. 14–38, 1921.
4. KIRK, S. R., Conodonts associated with the Ordovician fish fauna of Colorado: *Am. Jour. Sci.*, 5th ser., vol. 18, 1929.
5. MCQUEEN, H. S., The Dutchtown, a new Lower Ordovician formation in southeastern Missouri: *Missouri Bur. Geology and Mines Bienn. Rept. 59*, 1937; *a*, appendix 1; *b*, pl. 1; *c*, p. 18.
6. ULRICH, E. O., Revision of the Paleozoic system: *Geol. Soc. America Bull.*, vol. 22, pl. 27, 1911.

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ATRYPA AND STROPHEODONTA FROM THE CEDAR VALLEY BEDS OF IOWA

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ABSTRACT

This paper is the first of a series on the brachiopods of the Cedar Valley limestone, a fauna of Devonian age including some 130 species. Twenty species of *Atrypa*, 12 of them new, and 17 species of *Stropheodonta*, of which 10 are new, are described and illustrated herein.

Atrypa is probably the most abundant genus, in species and individuals, in the Cedar Valley beds. There are few outcrops which do not yield several specimens of one or more kinds. These species have all been listed as *Atrypa reticularis* (Linnaeus) in recent geological reports on counties in Iowa, but they seem to have little in common, specifically, with that Silurian shell. As so identified this group of brachiopods has been worthless in stratigraphy. However, these species of *Atrypa* are valuable guide fossils, for they differ greatly in form and have limited vertical ranges. For this reason they are here described as distinct forms.

In the Cedar Valley limestone of Iowa *Stropheodonta* is exceeded in numbers, either individually or specifically, only by *Atrypa*. Most of the species have short ranges, are fairly abundant and easily recognized, and consequently are good horizon markers. In number and variety the development of the genus in this formation parallels that so well displayed in the Snyder Creek beds of the Devonian of Missouri. No species, however, is common to the two faunas. Likewise, none of the Cedar Valley forms is recognized in the Devonian of eastern North America. Reported occurrences of *Stropheodonta plicata* at Thedford, Ontario, and at the Falls of the Ohio are probably erroneous. Also the species in the Schoharie grit that has been described as *Stropheodonta parva* Hall is different and should be renamed since *S. parva* Owen has precedence.

The illustrations are all approximately natural size, not varying by more than one millimeter in any instance. Specimens bearing numbers preceded by S. U. I. are in the collection of the State University of Iowa; those bearing M. A. S. are in the collection of the writer. Most of the photographs have not been retouched, but a few have been outlined or lightly deepened in some detail.

SYSTEMATIC DESCRIPTIONS

Order TELOTREMATA Beecher

Superfamily SPIRIFERACEA Waagen

Family ATRYPIDAE Gill

Genus ATRYPA Dalman, 1827

ATRYPA INDEPENDENSIS Webster

Plate 30, figures 10, 15–16

Atrypa reticularis Hall (pars). HALL and WHITNEY, *1858*, Geological Survey of Iowa, vol. 1, pt. 2, p. 515, pl. 6, figs. 4, 5.—THOMAS, *1916*, Iowa Acad. Sci. Proc. vol. 23, pp. 173–177, pl. 5 C, figs. 1–8.

Atrypa independensis WEBSTER, *1921*, Am. Midland Naturalist, vol. 7, p. 15, pl. 8, figs. 4–6.—FENTON and FENTON, *1932*, Am. Midland Naturalist, vol. 13, p. 206, fig. 1, pl. 21, figs. 1–4.—FENTON and FENTON, *1935*, Jour. Paleontology, vol. 9, pp. 377–9, pl. 41, figs. 9–12; pl. 42, figs. 14–16; pl. 43, fig. 12.

Atrypa expansa WEBSTER, *1921*, Am. Midland Naturalist, vol. 7, pp. 15–16.

Shell large, subequally biconvex, gib-

bous in maturity, subquadrate in outline with rounded anterolateral margins, wider than long, broadest posterior to the midlength, highly sinuate along the front margin, with the hinge line straight and less than the greatest width. Measurements of three hypotypes: length, 44.9 mm., 22.4 mm., and 22.4.; width, 46.8 mm., 33 mm., and 21.2 mm.; thickness, 28.2 mm., 16 mm., and 11.2 mm.

Pedicle valve strongly convex, strongly and evenly arched along the midline from beak to front, gently arched transversely, a little convex in the umbonal region, and slightly concave near the cardinal angles. Depressed anteriorly by a broad shallow sinus, absent in youthful specimens but increasing in size with maturity; so strongly developed in old shells that the anterior portion is nearly at right angles to the plane of the valve. Beak small, acuminate, projecting a little and incurved over that of the brachial valve, perforated by a small circular foramen. Delthyrium closed by two flat deltidial plates. Internally the muscle area is broadly triangular, wider toward the front but not sharply divided from the remainder of the valve anteriorly. Beyond the scars the surface is marked by numerous ovarian pits and undulating vascular ridges.

Brachial valve more convex than the pedicle; strongly arched along the midline from the anterior margin to the beak, with the curvature greatest in the umbonal region; highly arched transversely, the surface sloping strongly from the midline to the lateral margins and flattened near the angles, the anterior portion forming a short convex fold, which is not distinctly separated from the lateral slopes. Beak broad, partly concealed by the opposite beak.

Surface of both valves marked by numerous radiating costae increasing by multiple bifurcation, and divided by furrows of equal width. Costae fine, about three generally occupying the space of two millimeters near the front margin. The median costa is especially noticeable in that it tends to be enlarged and to give off costae on either side. Occasional specimens have larger costae, in some instances nearly twice the average size. Three costae have been noted to occupy the space of four or even five millimeters near the anterior margin. This difference in costal size is distinctly noticeable in selected specimens, and may be of varietal significance; yet a large suite contains so many intermediate forms that it cannot readily be separated into two groups on the basis of the costae. As individuals of both types occur in the same layer and in the same locality, it seems best to regard them as belonging to one variable species.

Growth lines are prominent, occurring at more or less regular intervals and usually crowded near the front and lateral margins. Most of the growth lines are smooth, but in well preserved specimens are distinctly lamellose; lamellae of several millimeters width are not uncommon. Exceptional gerontic individuals may have costate lamellae an inch or more in width.[1] The finely and coarsely costate forms alike develop these growth laminae, although more strongly so in the coarse individuals. Laminate and non-laminate individuals occur in the same layers and to some extent the lack of laminae in many shells is due to loss on weathering or on extraction from the enclosing limestone. *A. expansa* Webster does not differ in any other particular from *A. independensis* and is included in this species.

Neanic individuals of *Atrypa independensis* are lens shaped, equally biconvex, about as long as wide and have no fold or sinus. With maturity the shell becomes wider than long, the brachial valve becomes more convex than the pedicle, and the fold and sinus increase progressively in size. The gerontic stage is characterized by gibbosity, by thick shells with strongly developed fold and sinus, and by numerous growth lamellae, often greatly extended.

Atrypa independensis is well marked

[1] THOMAS, A. O., *Iowa Acad. Sci. Proc.*, vol. 23, p. 173 et seq.

and easily recognized. It is a conspicuous member of the faunule of which it is a part and of which it is by far the most numerous individually. This is the form originally described by Hall as *Atrypa reticularis* in the Geology of Iowa. He listed it as occurring at Lime Creek, Buffalo, Iowa; and Rock Island, Illinois. His illustrations, however, are all of the species described above. Webster applies Hall's description in defining his *Atrypa independensis*.

Occurrence.—The most common and characteristic fossil of the basal portion of the Cedar Valley beds, which are therefore named the *independensis* zone. Abundant at Independence, Solon, Waverly, Vinton, Linn Junction, and elsewhere.

Types.—Hypotypes, M. A. S. 309, 311, 480, 481, 482, 483 and 485.

ATRYPA BREMERENSIS
Stainbrook, n. sp.
Plate 31, figures 11–14

Shell of medium size or larger, subtriangular in outline, sharply curved at the angles and broadly so along the anterolateral margins, strongly and unequally biconvex, broadest posterior to the midlength, strongly sinuous along the front margin. Dimensions of the holotype: length, 23.4 mm.; width, 21.6 mm.; thickness, 17.2 mm. A distorted specimen is 21.1 mm. thick and is wider than long.

Pedicle valve strongly and regularly arched from beak to front along the midline, gently elevated in the umbonal region, slightly depressed along the lateral margins, depressed anteriorly by a broad shallow indistinctly defined sinus, which is continued anteriorly to form an angular linguiform extension. Beak small, pointed, a little incurved, pierced by a small circular foramen. Interior unknown.

Brachial valve more convex than the pedicle, strongly arched from beak to front with the greatest curvature over the umbo, the surface greatly elevated along the midline, descending thence abruptly to the lateral margins, and flexed anteriorly into a short low fold. Beak concealed by that of the opposite valve. Interior unknown.

Growth lines numerous, regularly spaced on the posterior portions of the valves, crowded anteriorly. Costae of medium size, low, broadly rounded, separated by narrower interspaces. Costae increasing by division and intercalation, accomplished two or three times from beak to front.

Atrypa bremerensis is smaller than *A. independensis*, is proportionately much more convex, and has larger costae. The discrepancy in the size of the costae is especially apparent in the early portions of the shell. The small size, the gibbosity and the distinctive shape of the shell readily separate this from other species of the genus in this area.

Occurrence.—*Independensis* zone of the Cedar Valley limestone at Waverly, Iowa.

Types.—Holotype, M. A. S. 312; paratype 315.

ATRYPA WATERLOOENSIS Webster
Plate 30, figures 1, 4

Atrypa waterlooensis WEBSTER, *1921*, Am. Midland Naturalist, vol. 7, p. 16.—FENTON and FENTON, *1935*, Jour. Paleontology, vol. 9, p. 370, pl. 37, figs. 9–13; pl. 38, figs. 11–14, pl. 39, figs. 1–6.

Shell large, plano-convex or concavo-convex, broadly subovate, with rounded angles and broadly rounded anterolateral margins, a little longer than wide, broadest posterior to the midlength, straight or slightly sinuous along the front margin. Hinge line straight and less than the greatest width. Measurements of three hypotypes: length, 43 mm., 46.4 mm., and 57.2 mm.; width, 42.1 mm., 43.6 mm., and 54.3 mm.; thickness 25.5 mm., 26 mm., and 26.1 mm.

Pedicle valve flat or somewhat concave, slightly convex in the umbonal region, and depressed laterally and anteriorly near the margins. Beak small, extending beyond and over that of the brachial valve, showing a small foramen

at the apex. Muscle area large, broad, flabelliform, longitudinally striated, occupying about one third of the valve, deeply sunken and bounded at the sides and front by a broad, rounded ridge, which becomes angular posteriorly. Remainder of the interior of valve marked by a few branched pallial ridges and crowded small ovarian pits.

Brachial valve highly convex, longer than the pedicle valve, strongly arched from beak to front with the curvature greatest posterior to the midlength; highest near the midpoint, with the surface sloping rapidly and evenly to the front and lateral margins and abruptly to the cardinal margin; depressed toward the angles; incurved beneath the beak. Umbonal region strongly developed and projecting beyond the hinge line.

Exterior of both valves marked by numerous radiating subangular variably sized costae separated by furrows nearly as wide. Costae very coarse, coarser than those of any other *Atrypa* in the Devonian of Iowa; about two in five millimeters near the front margin of large shells; increasing by multiple division and intercalation. Growth lines prominent, more or less regularly spaced in the posterior portion of the shell, often crowded near the front margin; more or less lamellose, sometimes strongly so, in gerontic individuals.

Atrypa waterlooensis is the largest species of the genus occurring in the Cedar Valley and is easily recognized by its very coarse costae and concavo-convex shape.

Occurrence.—*Waterlooensis* zone of the Cedar Valley limestone at Waterloo, Brandon, Littleton, Iowa City and Mid River. Widespread in the northern part of the Cedar Valley area of Iowa but replaced by a different form in the southern part.

Types.—Syntypes, U. S. National Museum 78588. Hypotypes, S. U. I. 6-182, 6-165, 6-169; M. A. S. 308, 449.

Atrypa brandonensis
Stainbrook, n. sp.

Plate 31, figures 1–2, 4

Shell large, subcircular, with lateral margins broadly rounded toward the front, concavo-convex, thickest posterior to the midlength, a little wider than long; widest near the midlength, hinge line less than the greatest width, cardinal angles rounded. Dimensions of the holotype and of a paratype: length, 38.1 mm., and 42.3 mm.; width, 43.2 mm., and 51.2 mm.; thickness, 21.1 mm., and 24.1 mm.

Pedicle valve moderately convex in the umbonal region, whence the surface slopes laterally with moderate rapidity and then curves upward to the margins, flattened toward the angles. Depressed anteriorly by a short, deep, narrow me-

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Explanation of Plate 30

Figs. *1, 4—Atrypa waterlooensis* Webster. *1*, Brachial view of a typical specimen, M.A.S. 449. *4*, Brachial view of a narrower individual. Both from Brandon, Iowa. (p. 231)

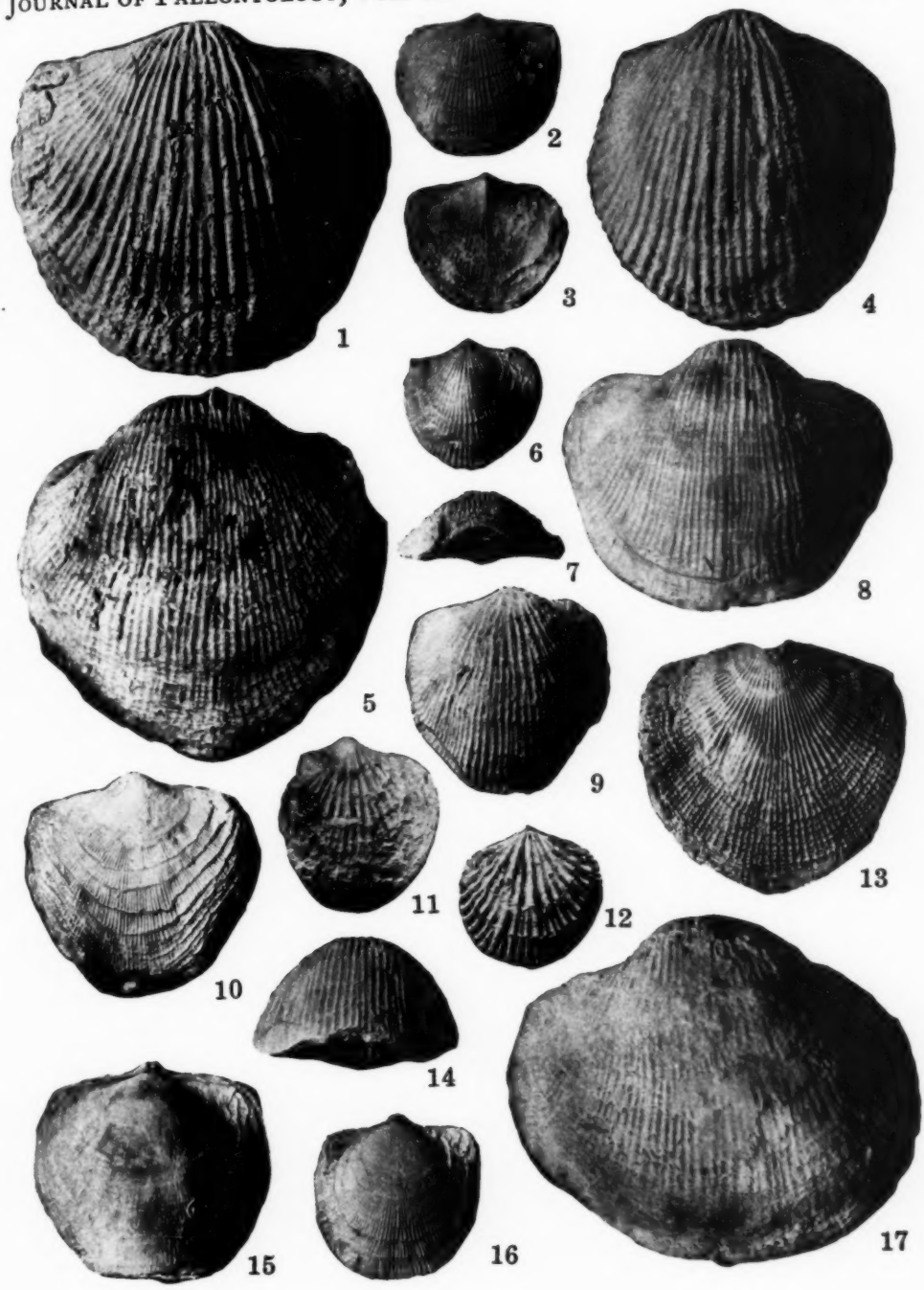
2, 3, 6, 7—Atrypa blackhawkensis Stainbrook, n. sp. *2, 3, 7*, Brachial, pedicle and anterior views of the holotype, M.A.S. 460. *6*, Brachial view of paratype. Both from the Burton Avenue quarry, Waterloo, Iowa. (p. 239)

5, 13, 17—Atrypa gigantea Webster. *5*, Brachial view of a specimen. *13*, Exterior of a pedicle valve, M.A.S. 450; both from north of Iowa City, Iowa. *17*, Pedicle view of specimen from the type locality at Linder's boathouse, Johnson County, Iowa, S.U.I. 6–164. (p. 233)

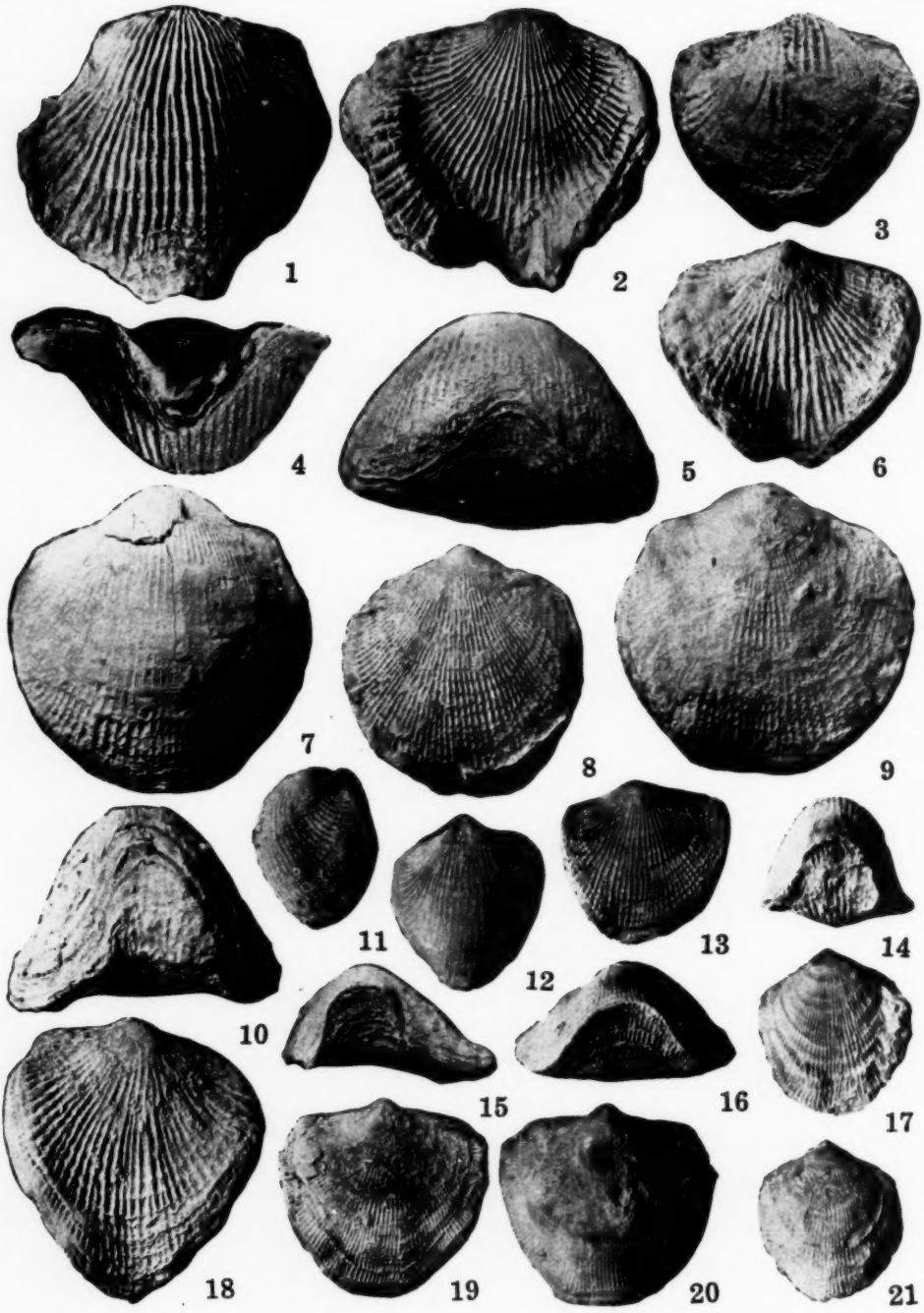
8—Atrypa waterlooensis var. *websteri* Fenton and Fenton. Pedicle view of a specimen, M.A.S. 496, from Brandon, Iowa, to compare with *A. gigantea*. (p. 234)

9, 11, 12, 14—Atrypa trowbridgei Fenton and Fenton. *9, 14*, Brachial and anterior views of a large specimen, M.A.S. 94. *12*, Brachial view of another example; both from Brandon, Iowa. *11*, Pedicle view of an incomplete specimen, S.U.I. 6–162, from Rapid Creek, Johnson County, Iowa. (p. 238)

10, 15, 16—Atrypa independensis Webster. *10, 15*, Pedicle and brachial views of a specimen, M.A.S. 483. *16*, Brachial view of a small specimen, M.A.S. 478; both from Waverly, Iowa. (p. 229)



Stainbrook, Devonian Brachiopods



Stainbrook, Devonian Brachiopods

dian sinus, the bottom rounded and strongly extended at the front into a lingual extension, which may be nearly at right angles to the plane of the valve.

Brachial valve more convex than the pedicle, greatest convexity posterior to the midlength, gently arched from the front margin to the umbo and strongly thence to the beak, abruptly arched transversely, flattened toward the angles. No median fold distinguishable, but the valve is considerably shortened along the midwidth by upturning of the pedicle sinus. Umbonal region prominent, projecting beyond the midlength. Beak completely concealed.

Surface of both valves marked by numerous radial costae, which increase by division. Costae of medium size, separated by narrow furrows, sharply elevated and rounded at the summit. Growth lamellae regularly spaced and far apart on the posterior half of the shell, more numerous and crowded near the front and lateral margins, where they may be extended several millimeters.

The form of the shell changes considerably during growth. In the neanic stage the valves are nearly equal, gently convex, and subcircular in outline. With the advance of maturity the shell becomes wider proportionately and more gibbous, the brachial valve becomes the more convex and the pedicle valve becomes concave toward the lateral and anterior margins. The gerontic stage shows the development of a strong mesial sinus in the pedicle valve and of crowded extended growth lamellae.

The typical shell is characterized by its medium to large size, strong costae, strongly sinuous front margin and the shortening of the valves along the midline. It has smaller costae than *Atrypa waterlooensis* and is strongly sinuous in front. The larger costae, different shape, and sinuate front margin separate this form from *Atrypa gigantea.*

This species resembles *Atrypa pronis* Fenton and Fenton and undoubtedly descended from that form. It is, however, more advanced in gerontic features, having more extended growth lamellae, coarser costae, and a larger shell with extended lateral margins.

Occurrence.— *Waterlooensis* zone of the Cedar Valley limestone in the *brandonensis* zonule, at Brandon, Iowa City and elsewhere.

Types.—Holotype, S. U. I. 6-161A; paratypes, S. U. I. 6-161 and M. A. S. 359.

ATRYPA GIGANTEA Webster

Plate 30, figures 5, 13, 17

Atrypa gigantea WEBSTER, *1921*, Am. Midland Naturalist, vol. 7, p. 16.—FENTON and FENTON, *1935*, Jour. Paleontology, vol. 9, p. 376.

Shell large, suborbicular, lateral margins broadly rounded, very unequally biconvex, wider than long, broadest poste-

EXPLANATION OF PLATE 31

FIGS. *1, 2, 4—Atrypa brandonensis* Stainbrook, n. sp. *1, 2*, Brachial view of the holotype, S.U.I. 6-161A. *4*, Pedicle and anterior view of a paratype, S.U.I. 6-161; both from Brandon, Iowa. (p. 232)

3, 6, 10, 18—Atrypa pronis Fenton and Fenton. *3, 6*, Brachial and pedicle views of a specimen from Littleton, Iowa, S.U.I. 6-153A. *10*, Anterior view of a specimen from Iowa City, Iowa. *18*, External view of a pedicle valve from Brandon, Iowa, S.U.I. 6-181. (p. 235)

5, 7–9—Atrypa randalia Stainbrook, n. sp. *5, 7, 9*, Anterior, brachial and pedicle views of the holotype, S.U.I. 6-183. *8*, Pedicle view of a paratype, M.A.S. 442; both from Randalia, Iowa. (p. 237)

11–14—Atrypa bremerensis Stainbrook, n. sp. *11–13*, Lateral, brachial and pedicle views of the holotype, M.A.S. 315. *14*, Anterior view of a paratype. M.A.S. 312; both from Waverly, Iowa. (p. 231)

15, 16, 19, 20—Atrypa scutiformis Stainbrook, n. sp. *15*, Anterior view of a paratype, M.A.S. 157. *16, 19, 20*, Anterior, pedicle and brachial views of the holotype, S.U.I. 6-150; both from the *waterlooensis* zone at Buffalo, Iowa. (p. 234)

17, 21—Atrypa littletonensis Fenton and Fenton. Pedicle and brachial views of hypotype, M.A.S. 440, from Littleton, Iowa. (p. 238)

rior to the midlength, hinge line straight and less than the greatest width, rounded at the angles. Dimensions of two hypotypes: length, 50 mm., and 39 mm.; width 58.7 mm., and 45.5 mm.; thickness, 27.6 mm., and 21.8 mm.

Pedicle valve gently concave, a little convex in the umbonal region, whence the surface slopes gently anteriorly and laterally and then rises to the margins. Beak short, pointed, incurved, pierced by a foramen at the apex. Greatly thickened interiorly. Muscle scars deeply sunken.

Brachial valve longer and more convex than the pedicle, greatest convexity posterior to the midlength; highest in the umbonal region; surface sloping with moderate rapidity to the front and lateral margins, flattened slightly near the angles, incurved beneath the beak. Umbonal region prominent, projecting a little beyond the hinge line.

Radiating costae numerous, less than medium size, increasing by division, about four or five in five millimeters on the umbonal region of a large specimen. Growth lines prominent, more crowded and lamellose near the anterior and lateral margins.

This species resembles *Atrypa waterlooensis* in shape, but is readily separated by its smaller costae, which are about half as large. It lies above that form in much of the Cedar Valley area. The form described as *Atrypa waterlooensis websteri* Fenton and Fenton is probably the same.

Occurrence.—Upper beds of the *waterlooensis* zone of the Cedar Valley limestone at Linder's boathouse, Iowa City, Buffalo, Linwood, Brandon, Waterloo and elsewhere.

Types.—Hypotypes, S. U. I. 6-164 and 6-170; M. A. S. 159, 313, 450, 451, 453.

ATRYPA SCUTIFORMIS
Stainbrook, n. sp.
Plate 31, figures 15–16, 19–20

Shell above medium size, subequally biconvex; outline shieldshaped, with nearly straight posterior margins, abruptly rounded angles and broadly curved anterolateral margins; wider than long, broadest posterior to the midlength, strongly sinuous along the front margin. Dimensions of the holotype and of two paratypes: length, 28.3 mm., 21.7 mm., and 20.4 mm.; width, 29.9 mm., 23.3 mm., and 22.5 mm.; thickness 15.9 mm., 12.1 mm., and 11.6 mm.

Pedicle valve strongly arched from beak to front along the midline, gently arched transversely at the midlength; a little elevated in the umbonal region, depressed on either side of it and flattened toward the cardinal angles. A broad shallow sinus, gently concave at the bottom and indistinctly defined at the sides, originates at the midlength and, widening and deepening toward the front, forms there a broadly rounded lingual extension. Beak small, pointed, incurving over the opposite beak and pierced at the apex by a small circular foramen. Interior unknown.

Brachial valve moderately arched along the midline, with the curvature greatest in the umbonal region, strongly arched transversely; the surface elevated and gently flattened along the midline, sloping abruptly thence to the lateral margins, a little flattened near the cardinal angles. Beak small, slightly projecting and concealed by that of the pedicle valve.

Exterior of both valves similarly marked by numerous fine radiating costae, regular in appearance, increasing by intercalation and division, and separated by spaces of equal width. About five costae occupy the space of three millimeters at the front margin. Growth lines widely spaced in the posterior portion of the shell, more numerous and closer together anteriorly, and occasionally so strongly lamellose as to interrupt the continuity of the costae.

This form resembles *Atrypa independensis* in shape and appearance but averages smaller and has finer costae. *A. independensis* averages about three costae in the space of three millimeters at the anterior margin. *Atrypa scutiforme*

belongs to the group of finely costate Atrypae of which *A. independensis* is typical.

Occurrence.—*Stropheodonta iowensis* zonule, *waterlooensis* zone of the Cedar Valley limestone. Carpenter's quarry, Muscatine County, is the type locality. Also found at Buffalo and elsewhere in the Devonian area of southeast Iowa.

Types.—Holotype, S. U. I. 6-150; paratypes, M. A. S. 157.

ATRYPA RUSTICA Stainbrook, n. sp.

Plate 32, figures 1–4

Shell above medium size, unequally biconvex, subtriangular, a little wider than long, broadest posterior to the midlength, rounded at the angles, broadly sinuous along the front margin. Dimensions of the holotype and of two paratypes: length, 28.9 mm., 28.1 mm. and 22.1 mm.; width, 30.5 mm., 28.6 mm., and 25.1 mm.; thickness 20.4 mm., 18.7 mm. and 14.7 mm.

Pedicle valve gently arched along the midline in the central portion and more strongly arched over the beak and near the anterior margin, gently arched transversely; surface elevated in the umbonal region, depressed slightly toward the angles, depressed anteriorly by a broad shallow sinus, which is indistinctly defined at the sides, and whose bottom is continued forward to form a broadly rounded lingual extension. Beak stout, projecting, a little incurved, and displaying a small circular foramen at the apex. Internal features unknown.

Brachial valve strongly arched from beak to front along the midline; curvature greatest in the umbonal region. Surface flattened a little along the midline and descending thence abruptly to the lateral margins. Beak small, slightly projecting, concealed by that of the opposite valve.

Surface of both valves marked by moderately coarse rounded radiating costae, which increase by division. Costae separated by slightly narrower intercostal spaces, about five in five millimeters near the front margin. Lamellose growth lines regularly developed and in general more numerous in the anterior portions of the shell.

This species is not easily confused with any other form in the Cedar Valley beds. The smaller costae separate it from *Atrypa trowbridgei*, with which it occurs. From *Atrypa devoniana* var. *tenuicosta* of the same zone it may be distinguished by its coarser costae. It is shorter proportionately than *Atrypa littletonensis* and has larger costae.

Occurrence.—*Bellula* zone of the Cedar Valley limestone at Brandon and elsewhere.

Types.—Holotype, M. A. S. 462; paratype, M. A. S. 461.

ATRYPA PRONIS Fenton and Fenton

Plate 31, figures 3, 6, 10, 18

Atrypa pronis FENTON and FENTON, *1935*, Jour. Paleontology, vol. 9, p. 375, pl. 40, figs. 4–8.

Shell of medium size and larger, broadly subtrigonal, gibbous, longer than wide in immature specimens and wider than long in adults, broadest posterior to the midlength; hinge line straight and a little less than the greatest width; acutely sinuate along the front margin. Measurements of three hypotypes: length, 34.6 mm., 31.1 mm., and 33.1 mm.; width, 37.9 mm., 28.8 mm., and 33.9 mm.; thickness, 26.7 mm., 20.1 mm., and 25.6 mm.

Pedicle valve strongly and regularly arched from beak to front along the midline, the curvature increasing anteriorly; gently convex in the umbonal region, concave toward the angles; depressed anteriorly by a broad shallow sinus, the floor of which is continued at the front to form a long angular linguiform extension. This extension in gerontic individuals may be at right angles to the plane of the valve and occasionally is inclined a little posteriorly.

Brachial valve strongly arched from back to front along the midline, the greatest curvature posterior to the midlength; acutely arched transversely, the

surface sloping abruptly from the midline to the lateral margins; flattened a little at the cardinal angles. Umbonal region prominent, projecting a little beyond the hinge line; beak concealed beneath that of the opposite valve.

Surface of both valves marked by numerous medium-sized costae increasing by division and separated by furrows of equal size. Growth lines prominent, few and far apart on the posterior portion of the valves, crowded and lamellose near the front and lateral margins.

Atrypa pronis is smaller and more convex than *A. brandonensis*, has slightly smaller costae, and has a larger, strongly angular lingual extension. It is unlike any other *Atrypa* in the Cedar Valley.

Occurrence.—Occurs in the lower part of the *waterlooensis* zone of the Cedar Valley limestone in the *pronis* zonule, at Brandon, Littleton, Iowa City, and elsewhere.

Types.—Hypotypes, S. U. I. 6-153A, 6-181, 6-156, 6-153, and M. A. S. 100, 124, 105, 144.

ATRYPA ONUSTA Fenton and Fenton

Plate 32, figures 15–16

Atrypa pronis onusta FENTON and FENTON, *1935*, Jour. Paleontology, vol. 9, p. 375, pl. 40, figs. 9–11.

Shell above medium size, a little wider than long, widest in the posterior portion, subquadrate, moderately sinuous along the front margin. Dimensions of three hypotypes: length, 30.6 mm., 33.6 mm. and 36.1 mm.; width, 33.2 mm., 36.9 mm., and 39.7 mm.; thickness 19.3 mm., 22.1 mm., and 30.2 mm.

Pedicle valve gently arched from beak to front, elevated in the umbonal region, shallowly concave toward the angles and along the lateral margins, depressed anteriorly by a broad shallow sinus, which is narrow and distinct in less mature specimens but broader and less distinct in larger gibbous individuals. In gerontic individuals the bottom of the sinus may be continued forward to form a short, broad lingual extension at right angles to the plane of the valve. Beak small, incurving, and bearing a small foramen. Molds of the interior show the muscle scars to be similar to those of other members of the genus.

Brachial valve more convex than the pedicle, arching regularly and rapidly from beak to front, with the curvature greatest over the umbo; more strongly arched transversely, with the surface depressed or flattened along the middle and sloping thence abruptly to the lateral margins; along the midline extends a narrow shallow sinus, which, in conjunction with the sinus of the opposite valve, indents or truncates the anterior median portion of the valve. Internal structures, as shown by molds, similar to those of the genus.

Costae of medium size, distinctly elevated, strongly convex along the summits, separated by narrower intercostal furrows, increasing by intercalation and division, and averaging about four in five millimeters in the middle of the valves near the front margin. Growth lines crowded along the margin, often lamellose.

The size of the shell, the size and strength of the costae and the sinus on the brachial valve are distinguishing characters. The bisinuate feature will readily separate it from other associated forms of this genus. More gibbous and gerontic individuals are distinctly flattened anteriorly and are characterized by a broad, short flat-bottomed sinus in the pedicle valve. *Atrypa onusta* is a well marked form with distinctive features and is here regarded as a separate species.

Occurrence.—Lower *waterlooensis* zone of the Cedar Valley limestone at Littleton, Brandon, and Waterloo.

Types.—Hypotypes, S. U. I. 6-152A, 6-152, 6-173, and M. A. S. 314, 489.

ATRYPA ROTUNDA Stainbrook, n. sp.

Plate 32, figures 10–14

Shell above medium size, gibbous, subovate, cardinal angles rounded, lateral margins gently curving to the front, a

little longer than wide, broadest near the midlength, gently to highly sinuate along the front margin. Dimensions of the holotype and of two paratypes: length, 22.1 mm., 23.8 mm., and 22.4 mm.; width, 21.8 mm., 23.1 mm., and 21.5 mm.; thickness 13.2 mm., 14.6 mm., and 19.5 mm.

Pedicle valve moderately convex, regularly arched from beak to front, in some examples strongly so, greatly arched transversely, flattened or slightly concave near the lateral margins, somewhat depressed anteriorly and mesially by a short, broad, very shallow sinus, the bottom of which may be extended in gerontic specimens into a linguiform extension at right angles to the plane of the valve. Beak strong, abruptly curved, projecting.

Brachial valve more convex than the pedicle, strongly and evenly arched along the midline and more strongly arched from side to side, flattened along the middle toward the front.

Radial costae of both valves small, narrow, separated by slightly narrower furrows and increasing by division on the pedicle valve and by intercalation on the brachial. Growth lines strong, lamellose, regularly spaced on the posterior part of the shell and crowded toward the front. Spaces between the growth lines marked by numerous fine concentric striae, which are more evident in the intercostal furrows.

Ephebic examples of this species are subequally biconvex with the brachial valve more strongly arched, longitudinally and transversely, than the opposite valve. Gerontic specimens, which may be smaller or larger than the average, are gibbous, almost spherical in shape, and have the pedicle valve strongly arched longitudinally and the brachial valve more strongly arched transversely; a broad, short, gently concave sinus with the bottom greatly extended is developed in the anterior median portion of the pedicle valve.

Atrypa rotunda differs from *A. devoniana* and its varieties as developed in the Cedar Valley beds in that it has distinctly larger costae and proportionately wider intercostal furrows, is longer than wide, attains a more nearly spherical shape, and has a more prominently developed lingual extension of the pedicle valve.

Occurrence.—*Cranaena iowensis* zone of the Cedar Valley limestone as developed at Iowa City, Linder's boathouse, Robert's Ferry, and Rapid Creek in Johnson County; Buffalo, and Linwood, Iowa.

Types.—Holotype, M. A. S. 240; paratypes, S. U. I. 6-163, M. A. S. 137, 145, 167.

ATRYPA RANDALIA Stainbrook, n. sp.

Plate 31, figures 5, 7–9

Shell above medium size, subcircular, gently sinuous along the front margin; obese individuals longer than wide, exceptionally subspherical. Dimensions of the holotype and of three paratypes: length, 35.1 mm., 35.4 mm., 33.2 mm. and 42.1 mm.; width, 33.5 mm., 40.5 mm., 32.3 mm., and 43.8 mm.; thickness, 22.8 mm., 31.5 mm., 28.1 mm. and 26.5 mm.

Pedicle valve gently to moderately convex, slightly elevated in the umbonal region, flattened or concave toward the angles and lateral margins. Depressed anteriorly by a short, broad, gently concave sinus; in some specimens elongated into a linguiform extension curved at right angles to the plane of the valve. Beak small, incurved, and pierced by a small foramen. Interior unknown.

Brachial valve more strongly convex than the pedicle, arching with strong regular curvature along the midline to the front, more strongly convex transversely, the surface descending abruptly to the lateral margins. Median front portion truncated by the pedicle lingual extension and occasionally elevated into a short, low, indistinct fold.

Costae of both valves numerous, radiating, of moderate size, rather acutely convex along the summits; separated by furrows of less width, increasing in num-

ber by intercalation and bifurcation on the brachial valve and by division on the pedicle; five to six occupy five millimeters near the front margin. Growth lines prominent, more or less irregularly spaced and often lamellose.

Its large size, its small costae, and its shape readily separate *Atrypa randalia* from other forms of this genus. Compared with *A. rotunda* of the same zone, it is much larger, has slightly coarser costae, and more strongly sinuous front margin. A somewhat similar form occurs in the southern portion of the Cedar Valley area at a higher level and may be a variety of this species.

Occurrence.—*Cranaena iowensis* zone of the Cedar Valley limestone at Randalia, Iowa.

Types.—Holotype, M. A. S. 442, paratypes 442, 442.

Atrypa littletonensis
Fenton and Fenton

Plate 31, figures 17, 21

Atrypa littletonensis Fenton and Fenton, *1930*, Am. Midland Naturalist, vol. 12, no. 1, pp. 13–14, pl. 2, figs. 3, 4.

Shell of medium size; elongate ovate, cardinal angles rounded and lateral margins making a more or less acute angle anteriorly; subequally biconvex, a little longer than wide, broadest posterior to the midlength. A hypotype from the type locality measures 22.9 mm. in length, 21.2 mm. in width, and 12.4 mm. in thickness.

Pedicle valve moderately arched along the midline from beak to front with the curvature greatest posterior to the midlength, broadly convex in the umbonal region; gently depressed anteriorly by a short, broad, shallow sinus, which is gently rounded at the bottom. Beak strong, pointed, projecting, incurved and bearing a small apical foramen.

Brachial valve regularly arched from the front margin to the beak, highest at the midpoint, more strongly arched transversely, surface sloping rapidly from the midline to the lateral margins.

Costae on both valves numerous, radial, increasing by division and implantation; fine, about eight occupying five millimeters near the front margin. Concentric growth lines numerous, fewer and farther apart in the posterior portion of the valves, elevated anteriorly so that the surface of the valves appears to be strongly wrinkled.

The small size, elongate shape, and the wrinkled surface distinguish this *Atrypa* from others in the Cedar Valley.

Occurrence.—*Profunda* beds of the Cedar Valley limestone at Littleton, Iowa.

Types.—Holotype, 594; paratypes, 595–596 in the University of Cincinnati Museum; hypotypes, M. A. S. 361.

Atrypa trowbridgei
Fenton and Fenton

Plate 30, figures 9, 11, 12, 14

Atrypa trowbridgei Fenton and Fenton, *1930*, Am. Midland Naturalist, vol. 12, no. 1, pp. 14–15, pl. 2, figs. 1–2.—Fenton and Fenton, *1935*, Jour. Paleontology, vol. 9, pp. 376–7, pl. 41, fig. 8; pl. 42, figs. 7, 8.

Shell of medium size or larger, unequally biconvex, ovate, a little longer than wide, broadest posterior to the midlength, narrowing toward the front and gently sinuous along the front margin. Measurements of three hypotypes: length, 19.4 mm., 24.6 mm., and 29.1 mm.; width, 21.5 mm., 26.1 mm. (restored) and 28.7 mm. (incomplete); thickness, 13.2 mm., 14.1 mm., and 18.2 mm.

Pedicle valve moderately arched from beak to front along the midline, curvature greatest over the umbo; gently elevated in the umbonal region, flattened or concave toward the angles and along the lateral margins; depressed centrally and anteriorly by a short, broad, shallow sinus whose bottom is flat or gently concave and is produced to form a short rounded lingual extension at the front. Beak stout, projecting and incurved.

Brachial valve regularly and strongly arched from beak to front and from side

to side, highest near the midpoint, whence the surface slopes with nearly equal rapidity to the front and lateral margins. A broad flattened fold, defined at the sides by gentle flexures, extends from the umbonal region to the anterior margin.

Costae of both valves numerous, rounded, radial; few, coarse, stout, and separated by wide furrows in the umbonal regions; more numerous, finer, and closer together near the front and lateral margins, where about six or seven occupy half a centimeter as compared with three or four on the umbones. Growth lines prominent, few, more or less regularly spaced, lamellose and sometimes marked by nodes where they cross the costae.

The small size and the marked difference in the size of the costae on the front and posterior portions of the valves readily separate this form from others in the Cedar Valley. A broader variety with a stronger fold and slightly smaller costae occurs in Johnson County at a slightly higher horizon.

Occurrence.—*Bellula* zone of the Cedar Valley limestone at Linn Junction, Brandon, Shellsburg, Iowa City, Solon and Buffalo.

Types.—Holotype, 26097; paratypes, 26098, 26099 in the Walker Museum, University of Chicago. Hypotypes, S. U. I. 6-160, 6-162 and M. A. S. 94, 151, 263, 454.

ATRYPA BLACKHAWKENSIS Stainbrook, n. sp.

Plate 30, figures 2, 3, 6, 7

Shell about medium size, subequally biconvex, wider than long, broadest a little posterior to the midlength, nearly straight along the hinge line, broadly curved along the lateral margins to the front, gently sinuous along the front margin in immature specimens but strongly so in gerontic individuals. The holotype and two paratypes measure 20.1 mm., 19.6 mm., and 26.7 mm. in length; 23.8 mm., 20.4 mm., and 28.4 mm. in width; and 9.5 mm., 11.3 mm., and 16.4 mm. in thickness.

Pedicle valve moderately arched from beak to front, with the curvature increasing slightly over the umbo; gently arched transversely; a little depressed toward the cardinal angles; elevated slightly in the umbonal region, which is marked by a short median ridge. Anterior portion depressed by a broad indistinctly defined sinus, which originates anterior to the midlength and forms at the front a short lingual extension. Sinus slightly developed in some individuals but prominent in gerontic specimens. Beak short, acute, pierced by a small circular apical foramen. Internal characters same as those of other representatives of the genus.

Brachial valve more convex than the pedicle, strongly arched along the middle from beak to front, curvature greatest in the umbonal region; surface flattened or gently depressed along the midline, sloping rapidly thence to the lateral margins and flattened toward the angles. Beak short, concealed beneath that of the opposite valve. Interior unknown.

Costae of both valves of medium stoutness, broadly rounded along their summits, separated by linear intercostal furrows; increasing by implantation and division, accomplished two or three times; diverging from the midline in characteristic fashion, especially in the umbonal region of the brachial valve. Growth lines strongly developed, regularly spaced in the posterior portion of the shell and often strongly lamellose.

The size of the costae, their divergence from the median line, and the peculiar shape of the shell distinguish *Atrypa blackhawkensis* readily from other forms near it in size.

Occurrence.—Coralville substage of the Cedar Valley limestone; topmost beds of the section at Waterloo, three or four feet above the lithographic limestone layer at the Burton Ave. quarry; and Nashua, Iowa.

Types.—Holotype, M. A. S. 307; paratypes, M. A. S. 460.

ATRYPA DEVONIANA Webster, and varieties

Plate 32, figures 5–9, 17–18, 22, 26

Atrypa devoniana WEBSTER, *1921*, Am. Midland Naturalist, vol. 7, p. 19. FENTON and FENTON, *1924*, Mich. Univ. Mus. Contr. Geology, vol. 1, pp. 134–136, pl. 26, figs. 16–24.

Shell above medium size, subovate, broadest posterior to the midlength and narrowing toward the front, width and length nearly equal, usually a little wider than long, occasionally longer than wide, strongly sinuate along the front margin. Dimensions of three hypotypes: length, 29.1 mm., 26.4 mm., and 22.6 mm.; width, 29.4 mm., 26.5 mm., and 22.8 mm.; thickness, 15.5 mm., 16.1 mm., and 15.3 mm.

Pedicle valve shallow; moderately arched from beak to front along the midline, curvature increasing toward the anterior margin, gently convex in the umbonal region; slightly concave toward the angles and along the lateral margins; depressed anteriorly by a short median sinus of moderate width and depth, gently concave at the bottom and produced at the front to form a short lingual extension. Beak short, sharply pointed, abruptly curved, bearing a small apical foramen.

Brachial valve gently arched from the anterior margin to the midpoint and abruptly thence to the beak; strongly arched transversely, surface sloping abruptly from the midline to the lateral margins; anterior median portion forming a fold more or less indistinctly defined at the sides.

Costae of both valves numerous, fine, radiating; rounded to angular along the summits; increasing by division; close together and separated by narrow furrows; about six occupying five millimeters between the umbo and front margin. Growth lines numerous, farther apart in the umbonal region, crowded at the front and often lamellose.

The above description is based on a number of specimens from the Cerro Gordo shale at Rockford, Iowa. The species also occurs in its typical form in the Independence shale. In several zones of the Cedar Valley limestone there are forms which, although varying in some details, may not be specifically distinct. Several, however, are distinctive of the beds in which they occur, are easily recognized and are here described as varietal forms.

Variety *tenuicosta* Stainbrook, n. var.: This form differs little from the type in general shape. It has slightly smaller costae separated by proportionately larger furrows; about seven or eight costae occupy the space of five millimeters near the front margin. This variety occurs in the *bellula* zone of the Cedar Valley limestone in the southern part of the Devonian area of Iowa, at Linder's Boathouse and elsewhere in Johnson County and at Buffalo and Linwood. Representatives of this form are S. U. I., 6-180 and M. A. S., 173.

Variety *bentonensis* Stainbrook, n. var.: This form is subcircular in outline, broadest near the midlength instead of posterior to it, and generally gibbous. The pedicle valve is more convex than that of the typical form, is scarcely depressed or very gently concave toward the angles. The fold and sinus are neither so large nor so distinctly defined. The costae are appreciably finer and farther apart, and the growth lines are rarely lamellose. This form is readily recognizable and is distinctive of the zone in which it occurs. Further study may show it to be a distinct species. *Pentamerella* zone of the Cedar Valley limestone at Brandon, Shellsburg, Iowa City, and Buffalo, Iowa. Paratypes, M. A. S. 93, 106, 110, 241; holotype, 93A.

Variety *minor* Stainbrook, n. var.: This form averages smaller, has noticeably finer costae, and is proportionately more convex from side to side. It is distinctly longer than wide and becomes more so with advancing maturity. The pedicle valve is moderately convex, is depressed or very gently concave toward the angles. The sinus of the pedicle valve

is absent in young individuals but is well developed in gerontic specimens. The growth lines are crowded and slightly lamellose near the margins. It differs from var. *tenuicosta* and var. *bentonensis* in its smaller size and more elongate shape. It occurs in a 6-foot zone with *Stropheodonta parva* lying immediately above the coral bed at Buffalo, Linwood, and Moscow. Holotype and paratypes, S. U. I. 6-158, 6-159; M. A. S. 171.

ATRYPA OCCIDENTALIS Hall

Plate 33, figures 40–44

Atrypa aspera var. *occidentalis* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 515, pl. 6, fig. 3, —HALL and CLARKE, *1895*, Pal. N. Y., vol. 8, pt. 2 pl. 55, figs. 18–20.
Atrypa aspera MEEK and WORTHEN, *1868*, Geol. Illinois, vol. 3, p. 403, pl. 13, fig. 7.
Atrypa hystrix occidentalis SCHUCHERT, *1897*, U. S. Geol. Survey Bull. 87, p. 152.

Shell above medium size, very unequally biconvex; subovate, wider than long, greatest width near the midlength, hinge line short and a little curved, cardinal angles rounded; front margin highly sinuous. Measurements of three hypotypes: length 13.4 mm., 12 mm., and 13.7 mm.; width, 16.2 mm., 14.1 mm., and 16.4 mm.; thickness, 16.7 mm., 18.6 mm., and 18.1 mm.

Pedicle valve moderately to strongly arched along the midline, greatest curvature anteriorly, gently convex in the umbonal region, flattened or depressed toward the cardinal angles and lateral margins, depressed anteriorly by a broad, shallow sinus, which is continued forward at the front to form a short curved linguiform extension. Beak pointed, strongly incurved, and bearing a small apical foramen.

Brachial valve highly convex, strongly arched from beak to front, greatest curvature posterior to the midlength, highly arched transversely, flattened a little along the midline; anterior median portion elevated into a short fold indistinctly separated from the lateral slopes and in most cases truncated by the lingual extension of the opposite valve.

Surface of both valves marked by broad, stout radial plications, rounded at the summit, separated by intercostal furrows of varying width and numbering about fifteen on either valve. Growth lamellae numerous, prominent, crowded near the front margin. Edges of the growth lamellae forming short, stout sharply pointed hollow spines several millimeters in length at the summit of each plication. The spines are seldom preserved but their former position is indicated by sharp upturn of the growth lamellae.

Occurrence.—Independensis zone, of the Cedar Valley limestone, characteristic of its upper beds. Originally described from Independence; occurs also at Troy Mills, Vinton, Linn Junction, Waverly, Solon, Davenport and Buffalo, Iowa.

Types.—Holotype, Am. Museum Nat. Hist. 5697; hypotypes, S. U. I. 6-157 and M. A. S. 260, 367, 368.

ATRYPA MASCULA Stainbrook, n. sp.

Plate 32, figures 19–21, 23–25

Shell medium to large, unequally biconvex, gibbous in the later stages, subtriangular, angles rounded, width and length variable, obese individuals often longer than wide, broadest posterior to the midlength, gently sinuous along the front margin. Measurements of the holotype and of several paratypes: length, 30.8 mm., 31.1 mm., 25.5 mm., and 26.8 mm.; width, 31.1 mm., 35.1 mm., 26.8 mm., and 27 mm.; thickness 21 mm., 25.4 mm., 15.1 mm., and 19.5 mm.

Pedicle valve moderately arched along the midline from beak to front, gently convex in the umbonal region, flattened or slightly concave toward the lateral margins; depressed anteriorly by a broad, shallow mesial sinus having a short lingual extension at the front. Beak strong, pointed, closely incurved over the opposite beak and bearing a small circular apical foramen.

Brachial valve highly convex, highest at the midpoint; strongly and regularly arched from back to front along the midline, greatest curvature over the umbo; highly arched from side to side, anterior

portion elevated into a short fold, indistinctly differentiated from the slopes.

Surface of both valves corrugated by numerous stout, broad radiating plications separated by narrower furrows and increasing by division. About thirteen to fifteen plications at the midlength of the valves. Growth lines lamellose and strongly developed, coarse, crowded near the margins and forming nodose elevations where they cross the plications. Nodes forming the bases of stout sharply pointed tapering spines, which may be a centimeter in length. The spines are missing from most specimens and appear on well preserved shells to have been absent on the umbonal region before burial. Between the lamellose growth lines are fine striae of increment.

Young shells are lenticular in shape, have few plications, and are very gently sinuous along the front margin. Gerontic shells are extremely gibbous, more sinuous along the anterior margin, and more coarsely plicate and lamellose. *Atrypa mascula* is larger than *Atrypa occidentalis*, coarser, more gibbous, has fewer and larger plications, and is not so highly sinuous along the front margin. The number of plications on the umbonal region of *Atrypa mascula* before division is about seven or eight, in *A. occidentalis* it is about ten.

Occurrence.—Occurs in a one-foot bed at the top of the *independensis* zone of the Cedar Valley limestone, and at the base of the *profunda* beds at Independence, Iowa. At Waverly it is found in a similar position but through a greater thickness of rock.

Types.—Holotype, S. U. I. 6-480A; paratypes, S. U. I. 6-480 and M. A. S. 63, 244.

ATRYPA BELLULA Stainbrook, n. sp.

Plate 33, figures 34–39

Shell small, subcircular to subelliptical, wider than long in immature shells, longer than wide in the later stages of growth, widest posterior to the midlength, slightly sinuous along the front margin. Dimensions of three specimens: length, 16.4 mm., 18.8 mm., and 21.5 mm.; width, 18.8 mm., 16.7 mm., and 21.9 mm.; thickness 10.1 mm., 14.7 mm., and 23.3 mm.

Pedicle valve gently convex to shallowly concave, gently convex in the umbonal region, slightly concave toward the angles and along the lateral margins, depressed anteriorly by a short, broad, shallow mesial sinus, which in gibbous specimens may be extended and curved toward the opposite valve. Beak short, curved, pierced by a small foramen.

Brachial valve highly convex, strongly and regularly arched from beak to front, moderately arched transversely when immature and strongly arched in gerontic specimens; anterior median portion more abruptly arched to form a short fold indistinctly defined from the lateral slopes.

Costae of medium size, stout, wide, rounded, rugose where crossed by growth lamellae, separated by furrows of nearly equal width, about twelve on each valve. Number of costae increasing irregularly by three or four along the front margin through division or intercalation. Growth lamellae finely laminar, numerous, crowded along the front and lateral margins, developing into hollow tapering spines six or seven millimeters long on the crests of the plications. In many specimens the spines are absent and the surface quite smooth, indicating that the spines may have been lost during life.

Atrypa bellula is smaller than *A. occidentalis*, has fewer and wider costae and a less sinuous front margin. Its smallness and its smaller costae readily separate *A. bellula* from *A. mascula*. It is smaller, proportionately longer, and has a more concave pedicle valve than *A. rockfordensis*.

Occurrence.—Abundant in the beds between the *profunda* and the *pentamerella* zones of the Cedar Valley limestone. These intervening beds are therefore called the *bellula* beds. Abundant at Brandon, Vinton, Shellsburg, Rapid Creek, Solon, Iowa City, Moscow, Davenport, Buffalo and Linwood, Iowa; Rock Island, Illinois.

Types.—Holotype, S. U. I. 6-477A; paratypes, S. U. I. 6-477, 6-188, 6-479, and M. A. S. 95, 153, 245.

Order PROTREMATA Beecher
Superfamily STROPHOMENACEA Schuchert
Family STROPHOMENIDAE King
Subfamily RAFINESQUININAE Schuchert
Genus STROPHEODONTA Hall, 1852
STROPHEODONTA HALLI Cleland

Plate 35, figures 1–3

Strophodonta demissa? OWEN, *1852*, Geological Survey of Wisconsin, Iowa, and Minnesota, p. 629, table 3A, fig. 14.

Strophodonta demissa HALL, *1858*, Geological Survey of the State of Iowa, vol. 1, pt. 2, p. 495, pl. 3, figs. 5a, b, c, d.—WHITFIELD, *1882*, Geology of Wisconsin, vol. 4, p. 327, pl. 25, fig. 18.—CLELAND, *1911*, Wisconsin Geological Survey Bull. 21, pp. 87–88, pl. 14, figs. 7–10.

Shell large, wider than long, transversely subelliptical with rounded anterolateral margins and extended cardinal angles, widest along the hinge line. Measurements of two hypotypes: length, 29.3 mm. and 24.2 mm.; width, 40.9 mm. and 35.1 mm.; thickness, 9.1 mm. and 9.4 mm.

Pedicle valve moderately convex, highest in the central part, the surface sloping gently away from the midpoint in all directions but more rapidly on approaching the anterior and lateral margins, depressed anterior to the cardinal extremities and elevated in the umbonal region; beak small, projecting a little beyond the hinge line; area flat, vertically striated, attaining in large specimens a height of more than 2 millimeters and gradually decreasing in height toward the extremities, inclined posteriorly and approaching the plane of the valve. Internally the broadly flabelliform muscle area extends anteriorly beyond the midlength and is more than half as wide as the valve. The area is marked by low angular radiating ridges and is distinct along the posterolateral border and indistinctly set off from the rest of the valve toward the front.

Brachial valve shallowly concave, flattened in the umbonal region, the surface curving upward evenly to the anterior and lateral margins and more abruptly to the cardinal margin; areas enclosed by the cardinal angles a little elevated and flat or gently concave; cardinal area half as high as that of the opposite valve, flat, vertically striated, and at right angles to the plane of the valve. Internally the apophyses of the cardinal process are short, stout, grooved at the extemities, widely divergent, and extended a little beyond the hinge line. The muscle scars are variably developed in different specimens, being weak in thin, less mature individuals and strong in old or thick shells. The posterior adductor scars are bordered laterally and anteriorly by low narrow distinct ridges, which, originating in front of and lateral to the cardinal process, extend forward for some distance and, turning inward and backward, border the anterior scars a short way. A narrow median septum rises between the front margins of the anterior adductors, increases in height toward the front, and ends abruptly shortly beyond the middle of the valve. Numerous papillae are scattered over the surface of the remainder of the valve but are more abundant and pronounced near the muscle scars. Several millimeters from the lateral and anterior margins the floor is elevated into a broad, low ridge marked by numerous transverse sinuses.

Along with several other members of the genus in the Cedar Valley formation *Stropheodonta halli* has usually been referred by geologists to *Stropheodonta demissa*. (HALL, JAMES, and WHITNEY, J. D., Report on the geological survey of the State of Iowa, vol. 1, pt. 2 (Paleontology), p. 496, 1858). In describing specimens from Iowa, Hall referred them to *Stropheodonta demissa* but noted that the New York form is

usually stronger, and more convex on the ventral valve, while the dorsal valve is often

nearly flat in its upper half, and bent upwards toward the margin; the area is likewise broader, being nearly double the width; the cardinal extremities less salient, and the striae more subdivided and finer in the middle and lower parts of the shell.

Cleland in his study of the Devonian of Wisconsin pointed this out and added that the western form is more transverse and the costae sharper, stronger, and fewer. He concluded that the differences are sufficient to delimit a new species and applied the name *S. halli* to the western form. Comparison of specimens from Iowa with several from Milwaukee shows that the form referred by Hall to *S. demissa* is *Stropheodonta halli* Cleland.

Hall's description seems certainly to have been applied to specimens from Buffalo and vicinity as the species is common there. Hall lists Independence as a locality, but search has revealed no specimens there referable to *Stropheodonta halli*. Lime Creek, indicated by Hall as another locality, is certainly doubtful.

Occurrence.—Typical of the *bellula* zone of the Cedar Valley limestone. The species has been collected at Buffalo, Rockingham, Pine Creek, Iowa City, Brandon, and Shellsburg in Iowa; Wisconsin; Illinois.

Types.—Hypotypes, S.U.I. 6-367, 6-374, 6-382; M.A.S. 35, 20, 6, 23.

STROPHEODONTA COSTATA Owen

Plate 33, figures 28–31

Strophodonta? costata OWEN, *1852*, Geological Survey of Wisconsin, Iowa, and Minnesota, pp. 585, 629, table 3, figs. 11, 11a; table 3A, fig. 5.

Stropheodonta? costata SCHUCHERT, *1897*, U. S. Geol. Survey Bull. 87, p. 421.

Shell small, gently to strongly concavo-convex, wider than long (exceptionally the length may approximate the width), subquadrangular in outline with the anterolateral margins rounded and the cardinal angles auriculate, greatest width along the hinge line or in front of it. Dimensions of several hypotypes: length, 13.5 mm., 15.2 mm., and 12.4 mm.; width, 16.6 mm., 18.7 mm., and 16.1 mm.; convexity of the pedicle valve, 5.5 mm., 5 mm., and 4.4 mm.

Pedicle valve moderately to strongly convex, the point of greatest convexity at the midpoint, the surface curving thence with moderate rapidity to the front and lateral margins and less rapidly to the hinge line, gently flattened or depressed in front of the umbo and depressed in front of the angles; beak small, pointed, slightly incurved; cardinal area flat or gently concave, highest beneath the beak and maintaining the same height nearly to the extremities, vertically striated, and inclined posteriorly at an angle of about 45° to the plane of the valve. Interior unknown.

Brachial valve moderately concave, the surface flat in the umbonal region and curving strongly upward to the lateral and anterior margins. Area flat, vertically striated, making a right angle with the plane of the valve, and about half as high or more than half as high as the opposite area. Internally the bifid cardinal process is short and stout, the apophyses are close together and slightly divergent. Muscle area elevated, the adductor scars outlined by narrow rounded ridges, and the median ridge not strongly developed but extending beyond the center of the valve. Near and parallel to the anterior and lateral margins is a low rounded ridge, beyond which the surface of the valve is abruptly deflected to the margins.

The surface of the pedicle valve is marked by moderately strong rounded to angular costae, which increase by intercalation accomplished three times from beak to front; the costae of the brachial valve are more rounded, wider, and increase by division. The costae on both valves vary in size, the longer ones being broader and more prominent. The intercostal spaces are as wide or wider than the costae and in most specimens are rounded at the bottom. Several prominent growth lines and numerous fine concentric striae cross the costae. Worn valves show the minutely punctate shell

substance and numerous fine longitudinal radiating striae on the costae.

Owen's type specimen of *Stropheodonta costata* is not among the others preserved in the U. S. National Museum; but it is fairly certain that he had at hand specimens of the form described immediately above. Owen noted that his specimen came from the Davenport limestone, and in his table of occurrences he places it in beds which he thought were equivalent to the Corniferous strata of the East. This horizon is the "Corniferous" of the Davenport geologists, which later became the upper Davenport of Norton. These beds are the strata that carry *Atrypa independensis* and are regarded in this paper as basal Cedar Valley. The *Stropheodonta* just described is the only one that fits Owen's description, horizon, and locality.

Stropheodonta costata is variable in size and shape; among the specimens in our possession are several that are smaller than the average, strongly convex, and wider at the midlength; there are others that are flatter and wider along the hinge line; there are also some rather large individuals that are more convex than those measured; some of these differences may be of varietal importance. *S. costata* differs from *S. plicata* in being smaller, less convex, and in possessing a less strongly developed umbonal region.

Occurrence.—*Atrypa independensis* zone of the Cedar Valley limestone. Common at Linn Junction, Solon, Davenport, and elsewhere in Iowa.

Types.—Hypotypes, S.U.I. 6-364 and 6-365; M.A.S. 17, 117, and 186.

STROPHEODONTA PARVA Owen

Plate 33, figures 25–27, 32–33

Strophodonta parva OWEN, *1852*, Geological Survey of Wisconsin, Iowa, and Minnesota, p. 584, table 3A, fig. 9.

Stropheodonta parva SCHUCHERT, *1897*, U. S. Geol. Survey Bull. 87, p. 425.

Shell delicate, below medium size, wider than long, depressed concavo-convex, subrectangular in outline with the angles a little auriculate, the lateral margins straight and parallel for the most part and merging anteriorly in a gradual curve with the front margin. Dimensions of two hypotypes: length, 15.4 mm., and 12.1 mm.; width, 19 mm., and 16 mm.; thickness, 5.6 mm., and 3.9 mm.

Pedicle valve moderately convex, the highest point posterior to the midlength, the surface sloping thence with gentle curvature to the lateral and anterior margins and more strongly on each side of the umbo to the hinge line, depressed a little near the cardinal extremities; umbonal region moderately prominent; beak small, scarcely projecting beyond the hinge line. Area low, highest beneath the beak, attaining there a height of nearly a millimeter and gradually decreasing in height toward the extremities; flat, vertically striated, and situated in the plane of the valve.

Brachial valve shallowly concave, flattened centrally and gently depressed in the region of the umbo; area flat, nearly as wide as that of the opposite valve and forming an obtuse angle with it. An incomplete brachial valve shows internal features characteristic of the genus *Stropheodonta*. The cardinal process is short, the muscle scars are faintly impressed, and the low median septum extends a short way beyond the midlength.

Surface of both valves broken by numerous fine angular costae, which are regular in appearance. Costae increasing by division and intercalation on the pedicle valve and by division on the brachial; three to four in the space of a millimeter at the front margin of a medium-sized specimen; crossed by few strong lines of growth and numerous fine concentric striae. In worn specimens the shell substance is longitudinally striated and minutely punctate.

Owen's types of this species have not been recovered, but his brief description, his measurements, and his illustration indicate that he had at hand specimens of the species described. However, Owen notes from 20 to 23 costae whereas some of our specimens show

nearly twice that many. The small size, the numerous fine costae, and the characteristic shape distinguish *S. parva* from other Devonian species.

Occurrence.—Uppermost part of the *Pentamerella* zone of the Cedar Valley limestone. Most of our specimens come from Walker's quarry near Buffalo, from Linwood, in Scott County, and from Atalissa, Iowa.

Types.—Hypotypes, S.U.I. 6-381; M.A.S. 178.

STROPHEODONTA PLICATA Hall

Plate 33, figures 1–5, 20

Strophodonta plicata HALL, *1860*, 13th Rept. New York State Cab. Nat. Hist., p. 90.—HALL, *1867*, New York Geol. Survey, Paleontology, vol. 4, p. 114.

Strophodonta plicata SCHUCHERT, *1897*, U. S. Geol. Survey Bull. 87, p. 426.

Shell about medium size; mature specimens strongly concavo-convex, about as long as wide, subquadrate in outline with slightly auriculate cardinal angles and rounded anterolateral margins, widest near the midlength, and with the hinge line generally less than the greatest width. Measurements of two hypotypes: length, 19.1 mm. and 19.1 mm.; width, 20.9 mm. and 18.7 mm.; thickness, 9.4 mm. and 7 mm.

Pedicle valve strongly convex, arched from beak to front and more strongly over the umbo, highest at the midpoint, from which the surface slopes rapidly to the anterior and lateral margins and more rapidly on each side of the umbo to the hinge line, a little flattened at the cardinal angles. Umbo strongly developed and projecting beyond the hinge line; beak small, blunt, and extended beyond the cardinal margin; area highest beneath the beak and decreasing in height rapidly toward the extremities, slightly concave, and situated in the plane of the valve. An incomplete valve shows the flabellate muscle scars and the crenulate hinge line characteristic of the genus.

Brachial valve gently to deeply concave, the surface depressed in the umbonal region and a little elevated at the angles; beak indistinguishable; area low, of nearly the same height throughout, and at right angles to the opposite area.

Surface of both valves marked by numerous stout angular costae, which are separated by intercostal spaces nearly as wide as the costae. Increase is by division accomplished several times, the costae being larger near the beaks and smaller near the front margin. The costae, variable in size and length, are arranged in groups giving them a fasciculate appearance characteristic of this form.

Comparison with the type specimen in the American Museum of Natural History removes all doubt as to the identity of the specimens at hand. Hall stated that he had a second specimen from Independence, Iowa, collected by St. John. The type specimen from a locality near Iowa City came from beds many feet higher. The specimen from Independence therefore seems certainly to have been a representative of the form described in this paper as *Strophodonta costata* var. *independensis*, from which *Strophodonta plicata* is distinguished by larger size, by greater convexity of the pedicle valve, and by the much coarser costae arranged in groups.

Occurrence.—*Cranaena iowensis* zone of the Cedar Valley limestone at Iowa City, Robert's Ferry, Coralville, Rapid Creek, and Linder's boathouse in Johnson County; Randalia, Iowa. It has been reported, probably erroneously, from Kentucky, New York, and Ontario.

Types.—Topotypes, S.U.I. 6-384 and M.A.S. 172; hypotypes, M.A.S. 25, 179, and 181.

STROPHEODONTA SUBDEMISSA Hall

Plate 35, figures 14–15, 17–18

Strophomena (*Strophodonta*) *subdemissa* HALL, *1857*, Tenth Rept. New York State Cab. Nat. Hist., p. 145.

Strophodonta subdemissa HALL, *1867*, New York Geol. Survey, Paleontology, vol. 4, pp. 114, 415–16, pl. 17, figs. 2h. 2i.

Shell medium to large, wider than long, with the greatest width along the hinge line, transversely subsemi-elliptical

in outline with the cardinal angles extended and auriculate and the anterolateral margins rounded. Dimensions of a hypotype, a medium-sized, nearly complete shell: length, 19.8 mm.; width, 31.2 mm.; convexity of pedicle valve, 7.5 mm.

Pedicle valve moderately convex, attaining its highest point in the center of the valve, whence the surface slopes laterally and anteriorly with moderate rapidity; gently convex in the umbonal region and depressed toward the cardinal extremities so as to give them an auriculate appearance; beak small, scarcely projecting; cardinal area low and decreasing but little in height until near the extremities, flat, vertically striated, and posteriorly inclined a little to the plane of the valve. Interior not known.

Brachial valve moderately concave, the surface flattened centrally but curving upward strongly to the lateral and front margins; area flat, nearly half as high as the opposite area and making a right angle with it. The internal characters are similar to those of other members of the genus.

Surface of both valves marked by numerous angular fairly strong costae, which increase by intercalation and bifurcation. They are more rugose and closer together in the posterior part of the valves and anteriorly are evenly spaced, about two occupying the space of a millimeter at the front margin. The intercostal spaces are as wide as the costae or wider and, like them are marked by numerous punctae where worn and by fine longitudinal radiating striae.

Strophеodonta subdemissa differs from *Strophеodonta halli* in the greater width in proportion to length and in the auriculate extension of the cardinal extremities.

Occurrence.—The species has been found only in the *independensis* zone of the Cedar Valley limestone. Our specimens were collected at Linn Junction, Solon, Independence, and Vinton, Iowa.

Types.—Hypotypes, S.U.I. 6-141, 6-140, and 6-142, and M.A.S. 11.

STROPHEODONTA CEDARENSIS

Stainbrook, n. sp.

Plate 34, figures 1–2, 5–6, 12

Shell large, wider than long, with the greatest width in most specimens near the midlength, subquadrate in outline with rounded anterolateral margins, possessing sharply defined cardinal angles and showing there a slight tendency toward auriculation. Dimensions of the holotype and of two paratypes: length, 38.8 mm., 34.1 mm., and 36.8 mm.; width, 47.1 mm., 42.8 mm., and 45 mm.; convexity of the pedicle valve, 12.6 mm., 10 mm., and 12.9 mm. A large incomplete specimen measures 46.5 mm. in length and 54.1 mm. in width.

Pedicle valve broadly convex, highest in the central part, from which the surface slopes uniformly and with moderate rapidity to the anterior and lateral margins but more rapidly to the cardinal margin; toward the cardinal extremities the surface is depressed at first and then curves upward a little, giving the angles an auriculate appearance; umbonal region gently convex; beak broad, projecting a little beyond the hinge line; area highest beneath the beak and gradually decreasing in height toward the extremities, flat, vertically striated and nearly coincident with the plane of the valve. Interior unknown.

Brachial valve concave, the surface curving upward evenly and gently from the central part to the anterior and lateral margins and more abruptly to the cardinal margin, flattened and a little elevated at the cardinal angles; umbonal region flat; area linear and inclined to the plane of the valve. Internally the cardinal process consists of two short, stout slightly divergent apophyses which are concave at their extremities and about 2 mm. distant from each other at their bases. The muscle area is elevated and similar in appearance to that of *Strophеodonta demissa*. The ridges bounding the posterior adductor scars are distinct, narrow, and elevated. Between the anterior margins of the anterior adduc-

tors rises a median septum, which increases in height and width toward the front until it ends abruptly at the midpoint. About half a centimeter from the anterior and front margins the floor of the valve is raised abruptly to form a narrow rounded elevated radially grooved ridge, beyond which the surface is strongly deflected to the margins.

The surface of both valves is marked by numerous fine costae, which are sharply angular, narrow, and separated by intercostal spaces as wide as the costae or wider. Increase is by intercalation on the pedicle valve and by division on the brachial. About six costae can be counted in the space of 5 millimeters near the front margin of a mature shell. Numerous concentric striae cross the costae, being especially prominent in the spaces between. Where the shell is worn the pores are numerous and plainly visible.

Strophеodonta cedarensis is the largest member of the genus yet recovered from the Cedar Valley beds. It is easily distinguished from *S. halli* by its larger size, its more convex shell, its proportionately greater width, and its finer, more regular costae.

Occurrence.—In the *waterlooensis* bed in the northern part of the Cedar Valley area at Brandon, Waterloo, and Littleton, Iowa.

Types.—Holotype, S.U.I. 6-63A; paratypes, S.U.I. 6-363, 6-375, and 6-376; M.A.S. 13, 22, and 160.

STROPHEODONTA COSTATA var. INDEPENDENSIS Stainbrook, n. var.

Plate 33, figures 15–18

Strophodonta plicata HALL (part), *1867*, New York Geol. Survey, Paleontology, vol. 4, p. 114.

Shell below medium size, depressed concavo-convex, wider than long, with the greatest width along the hinge line, quadrate in outline with the front margin rounded. Dimensions of the holotype and of a paratype: length, 18 mm. and 18 mm.; width, 22 mm. and 20 mm.; convexity of the pedicle valve, 6.2 mm. and 6.8 mm.

Pedicle valve moderately convex, the surface highest in the central part of the valve and sloping thence with equal rapidity to the margins, slightly auriculate at the cardinal angles, flattened or gently convex in the umbonal region;

EXPLANATION OF PLATE 32

FIGS. *1–4—Atrypa rustica* Stainbrook, n. sp. Pedicle, brachial, lateral and anterior views of the holotype, M.A.S. 462, from Brandon, Iowa. (p. 235)

5–8—Atrypa devoniana var. *bentonensis* Stainbrook, n. var. Pedicle, brachial, lateral and anterior views of the holotype from the *pentamerella* zone at Brandon, Iowa, M.A.S. 241A. (p. 240)

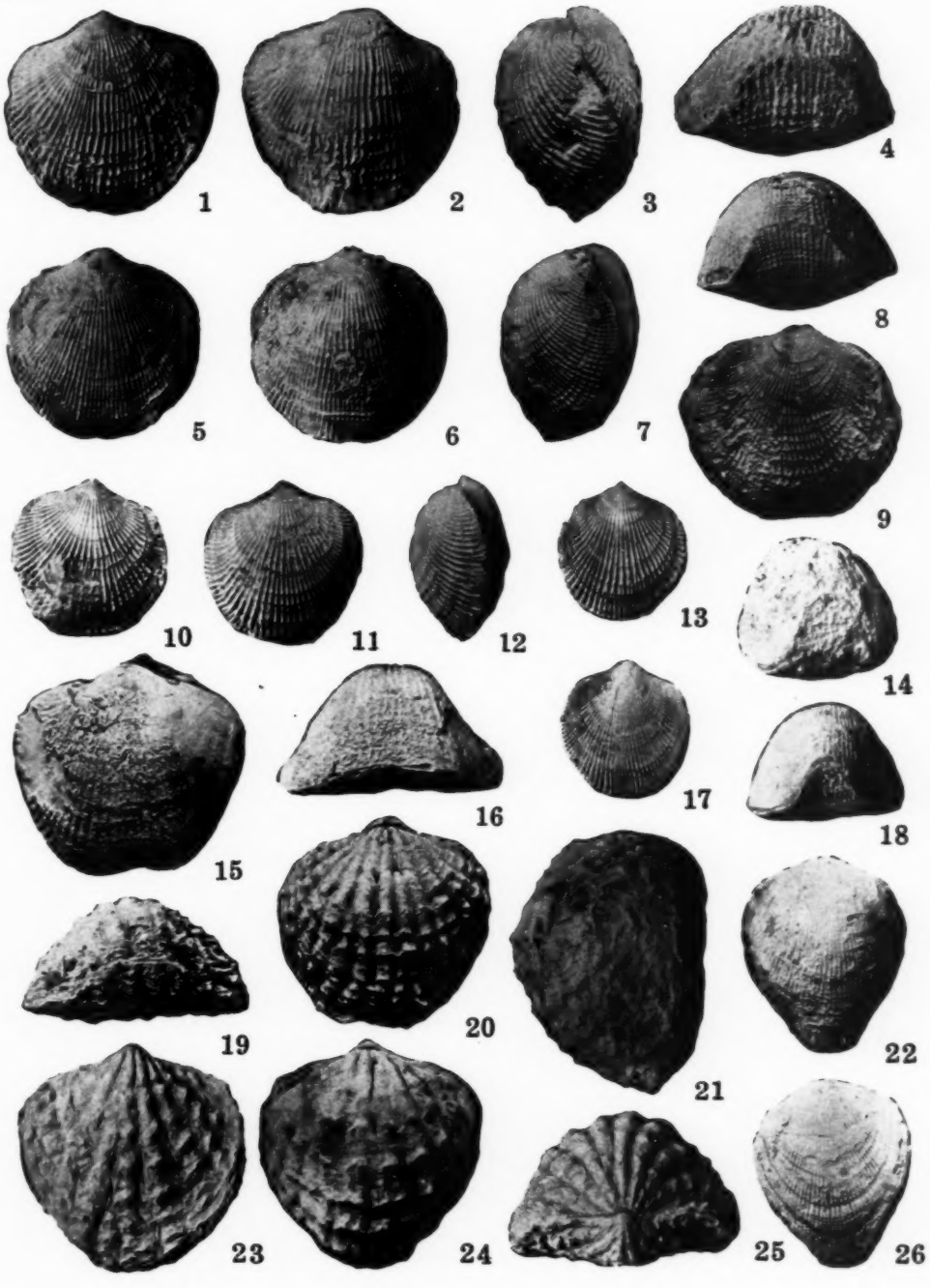
9—Atrypa devoniana var. *tenuicosta* Stainbrook, n. var. Pedicle view of the holotype from the *bellula* zone at Linder's boathouse, Johnson County, Iowa, S.U.I. 6-180. (p. 240)

10–14—Atrypa rotunda Stainbrook, n. sp. *10–12*, Pedicle, brachial and lateral views of the holotype, Lost Creek, Johnson County, Iowa, M.A.S. 137. *13*, Pedicle view of a nearly perfect paratype, M.A.S. 240, from the same locality. *14*, Anterior view of a nearly spherical specimen from Mid River, Johnson County, Iowa, S.U.I. 6-153. (p. 236)

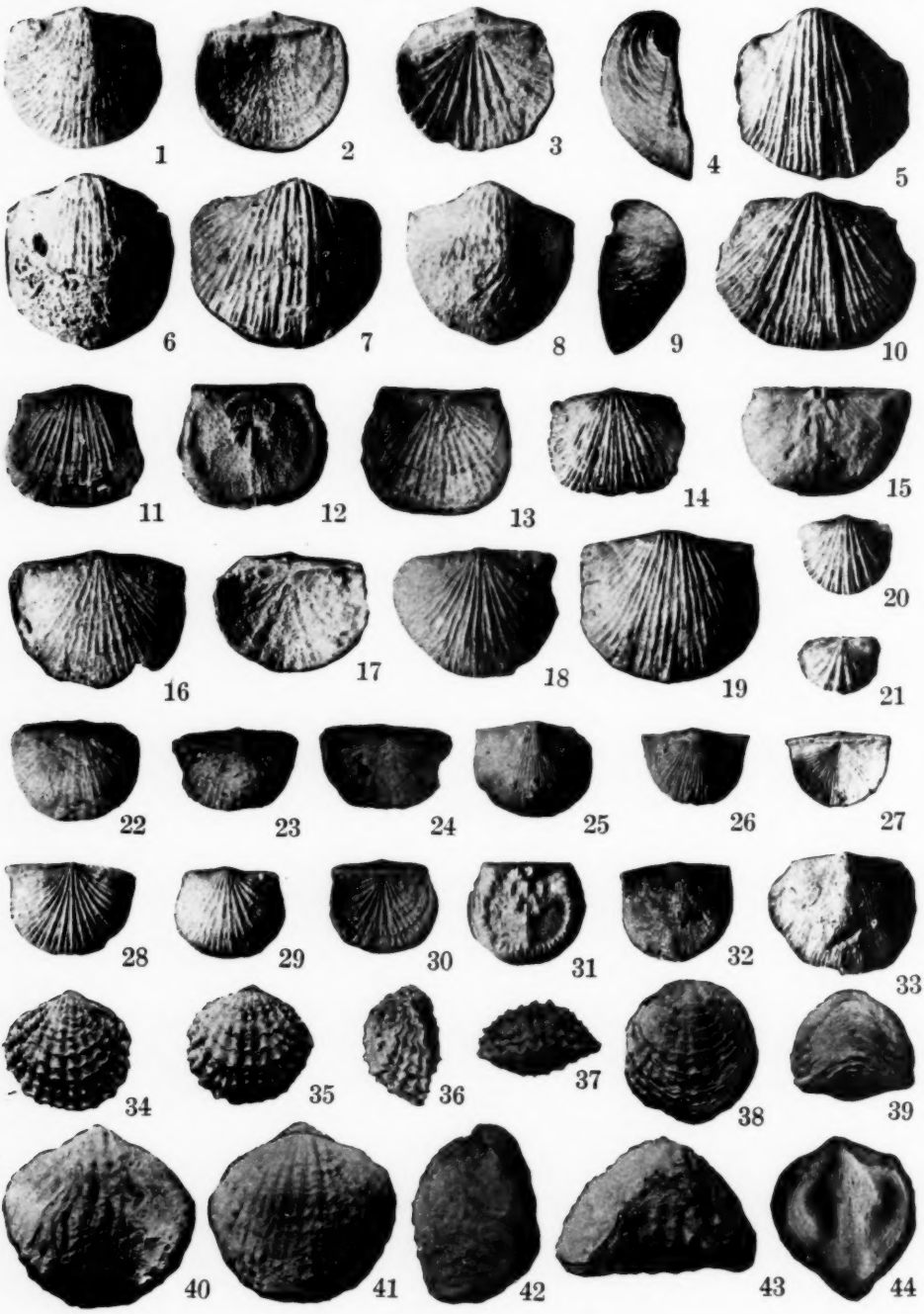
15–16—Atrypa onusta Fenton and Fenton. Brachial and anterior views of a specimen from Littleton, Iowa, S.U.I. 6-152A. (p. 236)

17, 18, 22, 26—Atrypa devoniana var. *minor* Stainbrook, n. var. *17*, Pedicle view of a paratype from Buffalo, Iowa, M.A.S. 171. *18, 22, 26*, Anterior, brachial and pedicle views of the holotype from the *Strophеodonta parva* zonule at Buffalo, Iowa, S.U.I. 6-158. (p. 240)

19–21, 23–25—Atrypa mascula Stainbrook, n. sp. *19, 20*, Anterior and brachial views of a paratype from Waverly, Iowa, M.A.S. 63. *21*, Lateral view of a large paratype, S.U.I. 6-480A. *23–25*, Pedicle, brachial and posterior views of the holotype, S.U.I. 6-480A; both specimens from Independence, Iowa. (p. 241)



Stainbrook, Devonian Brachiopods



Stainbrook, Devonian Brachiopods

beak small and projecting a little beyond the hinge line; area about a millimeter high beneath the beak and becoming lower toward the extremities, gently curving, vertically striated, and posteriorly inclined nearly to the plane of the valve. Interior unknown.

Brachial valve gently concave, the surface flat in the region of the umbo and for a short distance anterior; beyond, it is curved strongly upward to the anterior and lateral margins; area low, half as high as opposite area, and at right angles to the plane of the valve. Internal characters similar to those displayed by other members of the genus; apophyses of the cardinal process short and but little divergent from each other.

Strong angular costae, few in number and arranged in sets mark the posterior part of the shell. Anteriorly the costae increase by intercalation and bifurcation and are finer and closer together at the margins, where about four or five occupy the space of 2 mm. The costae of the brachial valve tend to be wider and more rounded. Numerous concentric striae of growth cross the costae, an occasional one being strongly impressed on the costae.

The species is similar in most respects to typical *Stropheodonta costata* of the same zone but it differs from that shell in being larger, less convex, and wider in proportion to length. A specimen collected by St. John and referred by Hall to *Stropheodonta plicata* seems to have been *S. costata* var. *independensis*, for *S. plicata* was described from rocks at Iowa City many feet higher than the strata at Independence. Besides this difference in horizon, *S. plicata* is more convex,

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EXPLANATION OF PLATE 33

FIGS. *1–5, 20—Stropheodonta plicata* Hall. *1–2*, Pedicle and brachial views of a hypotype, S.U.I. 6-384. *3*, Brachial view of another, M.A.S. 179. *4–5*, Lateral and pedicle views of a large specimen, S.U.I. 6-384, from Mid River, Johnson County, Iowa. *20*, Pedicle view of a small specimen from North Liberty, Iowa, introduced for comparison with *S. occidentalis*. (p. 246)

6–9, 19—Stropheodonta umbonata Stainbrook, n. sp. *6*, Pedicle view of the holotype, S.U.I. 6-350A. *8, 9*, Pedicle and lateral views of a paratype, S.U.I. 6-350; both from Solon, Iowa. *7, 19*, Pedicle views of two paratypes, M.A.S. 27; both from Linder's boathouse, North of Iowa City, Iowa. (p. 252)

10–14—Stropheodonta quadratella Stainbrook, n. sp. *10, 14*, Pedicle views of two paratypes, M.A.S. 182. *11*, Pedicle view of the holotype, M.A.S. 182A. *12, 13*, Internal and external views of a brachial valve, M.A.S. 182. All from Randalia, Iowa. (p. 254)

15–18—Stropheodonta costata var. *independensis* Stainbrook, n. var. *15*, Interior view of a brachial valve, S.U.I. 6-369. *16*, Pedicle view of a paratype, S.U.I. 6-364. *17*, Brachial view of a paratype, M.A.S. 177. *18*, Pedicle view of the holotype, S.U.I. 6-369A. All from Independence, Iowa. (p. 248)

21—Stropheodonta occidens (Hall.) Pedicle view of a hypotype from Iowa City, Iowa, M.A.S. 498. (p. 255)

22–24—Stropheodonta solonensis Stainbrook, n. sp. *22*, Pedicle view of a paratype, M.A.S. 22. *23, 24*, Pedicle and brachial views of the holotype, M.A.S. 224; both from Solon, Iowa. (p. 254)

25–27, 32, 33—Stropheodonta parva Owen. *26–27*, Pedicle and brachial views of a small hypotype, S.U.I. 6-381. *25, 32, 33*, Pedicle views of three hypotypes, M.A.S. 178. All from Buffalo, Iowa. (p. 245)

28–31—Stropheodonta costata Owen. *28*, Pedicle view of a typical specimen, M.A.S. 186. *29, 30*, Pedicle and brachial views of a hypotype, S.U.I. 6-364. *31*, Internal view of a brachial valve, S.U.I. 6-364. All from Linn Junction, Iowa. (p. 244)

34–39—Atrypa bellula Stainbrook, n. sp. *34–37*, Pedicle, brachial, lateral and anterior views of the holotype from Brandon, Iowa, M.A.S. 95. *38, 39*, Pedicle and anterior views of a paratype from the same locality. (p. 242)

40–44—Atrypa occidentalis Hall. *40–43*, Pedicle, brachial, lateral and anterior views of a hypotype, M.A.S. 260. *44*, Internal view of a pedicle valve, S.U.I. 6-157. Both from Independence, Iowa. (p. 241)

more elongate, and has a more pronounced umbonal region as well as fasciculate costae.

This species has in general a northerly distribution in the State, whereas the more typical form is strictly southern.

Occurrence.—*Independensis* zone of the Cedar Valley limestone at Independence, Iowa, and vicinity.

Types.—Holotype, S.U.I. 6-369A; paratypes, S.U.I. 6-369, 6-362, and M.A.S. 174, 177, and 228.

STROPHEODONTA IOWENSIS Owen

Plate 34, figures 3, 4, 7

Strophodonta iowensis OWEN, *1852*, Geological Survey of Wisconsin, Iowa, and Minnesota, p. 585.

Stropheodonta iowaensis SCHUCHERT, *1897*, U. S. Geol. Survey Bull. 87, p. 423.

Shell of medium size, thin, depressed concavo-convex, semielliptical in shape with slightly extended cardinal angles and rounded anterolateral margins, greatest width along the hinge line or in front of it. Measurements of two hypotypes: length, 19.3 mm. and 17.5 mm.; width, 27 mm. and 24.6 mm.; thickness, 3.9 mm. and 4.1 mm.

Pedicle valve depressed convex, flattened centrally, highest in the umbonal region whence the surface slopes gently and evenly to the anterior and lateral margins and to the cardinal margin on each side of the umbo; beak small, sharp, and projecting a little beyond the hinge line; area highest beneath the beak and decreasing in height gradually toward the extremities, flat or slightly curved, and inclined at an angle of 45° to the plane of the valve.

Brachial valve shallowly concave, flattened in the umbonal region and sloping upward with a gentle curvature near the anterior and lateral margins; beak indistinguishable; area low and at right angles to the opposite area.

Surface of both valves marked by numerous radiating angular costae, which vary in length and coarseness and which increase by division on both valves. Growth lines uncommon but strongly developed in some specimens.

The types of this species are not among others in the U. S. National Museum and apparently have been lost. Owen's description is meager and without an illustration, but he notes that *Stropheodonta iowensis* is smaller than that shown in figure 14, which represents his *S. dimosa*?, that it has the convex valve only flatly arched, and that it has a width of about $\frac{7}{8}$ inch. He obtained his specimens from the limestones along Pine Creek, and from this locality we have obtained several specimens. There seems little doubt from the occurrence, the description, and the size that we have at hand individuals of Owen's *S. iowensis*.

Stropheodonta iowensis is distinguishable from *S. parva* by the larger size, the flatness of the shell, and the larger, more irregular costae. The thinness of the shell, the smaller size, and the flatness distinguish it from *S. halli* and *S. cedarensis*.

Occurrence.—This form occurs in the part of the Cedar Valley limestone equivalent to the *waterlooensis* beds of the northern part of the area. The specimens are so abundant that the layer in which they occur may be designated as the *Stropheodonta iowensis* zonule. Our specimens were collected in Dodge's Ravine, at Buffalo, in Scott County, and along Pine Creek in Muscatine County, Iowa.

Types.—Hypotypes, S.U.I. 6-383 and M.A.S. 2.

STROPHEODONTA RANDALIA Stainbrook, n. sp.

Plate 35, figures 8, 9, 11, 12

Shell above medium size, wider than long, with the hinge line equal to the greatest width or less, subquadrangular in outline, with the cardinal angles but little extended and the anterolateral margins rounded. Dimensions of the holotype and two paratypes: length, 23.2 mm., 27.4 mm., and 28.7 mm.; width, 29.5 mm., 32.4 mm., and 34.1

mm.; convexity of the pedicle valve, 7.5 mm., 11.8 mm., and 9.8 mm.

Pedicle valve moderately convex, highest at the midpoint, whence the surface curves strongly to the margins, depressed slightly toward the cardinal angles and elevated a little in the umbonal region, which, in gibbous specimens, tends to project beyond the hinge line; beak small and projecting a little; area moderately high beneath the beak, gradually becoming lower toward the extremities, slightly concave, and situated in the plane of the valve. The internal characters are similar to those of the genotype, *Stropheodonta demissa*.

Brachial valve moderately concave, flat in the umbonal region and anterior to the hinge line but strongly upcurved toward and near the lateral and front margins; area about two-thirds as high as that of the pedicle valve and making a right angle with it. Internally the muscle area is strongly elevated and similar in appearance to that of *S. demissa*.

Costae of both valves numerous, coarse, narrow, somewhat irregular and unequal in size; those of the brachial valve increase by division and tend to be coarser, more rounded, and closer together than those of the pedicle valve, which increase by intercalation; separated by intercostal spaces as broad as the costae or broader and crossed by numerous fine concentric striae. Growth lines uncommon but in some specimens so well developed as to interrupt the continuity of the costae.

This species is not easily confused with any other *Stropheodonta* occurring in the Cedar Valley beds. It differs from *S. linderi* in its smaller size, the greater convexity of the pedicle valve, greater length in proportion to width, and in the possession of larger, more angular, and less numerous costae. It is larger, thicker, more convex, and more transverse than *S. iowensis*, and the costae are larger and less numerous. It is smaller than either *S. halli* or *S. cedarensis*, attains a proportionately greater convexity, and has larger less numerous and more widely spaced costae. It is larger, flatter, and proportionately wider than *S. plicata*, with which it is associated.

Occurrence.—*Cranaena iowensis* zone of the Cedar Valley limestone at the abandoned railroad cut at Randalia; Iowa City, Lost Creek, and Linder's boathouse in Johnson County, Iowa.

Types.—Holotype, S.U.I. 6-380A; paratypes, S.U.I. 6-380 and M.A.S. 183, 184, and 272.

STROPHEODONTA RETICULATA
Stainbrook, n. sp.
Plate 35, figure 5

Shell large, wider than long, subquadrate in outline with nearly straight lateral margins and broadly rounded anterolateral margins, widest along the hinge line or a little anterior to it, auriculate at the extremities. Dimensions of the holotype and of an incomplete paratype: length, 31.5 mm. and 32 mm.; width, 46.7 mm. and 42 mm. (restored).

Pedicle valve strongly convex, highest near the midlength, whence the surface curves with moderate rapidity to the hinge line and rapidly to the lateral and front margins; umbo but slightly elevated; beak small; area low, of the same height nearly to the extremities, vertically striated, unmarked by deltidium or opening, and inclined to the plane of the valve. Muscle scars large, flabelliform, extending halfway to the anterior margin.

Brachial valve gently convex, flat for the greater part but curving upward with moderate rapidity to the anterior and lateral margins; area low, linear.

Pedicle valve marked externally by numerous strong angular plications, which increase by intercalation and which are 1 to 2 mm. apart. In the slightly concave areas between the plications are from three to four smaller fine simple radiating costae. Crossing the plications and especially prominent between the costae are closely crowded fine minute concentric ridges, which give

the spaces between the plications a reticulate appearance. The markings of the brachial valve are similar but the plications are smaller and farther apart and have between them from 10 to 12 costae. The shell is punctate where worn.

This species is known only from several incomplete specimens. The shell is thin and scales off readily as it adheres strongly to the tough limestone matrix in which the fossils are preserved. The valves are widely separated, leaving a living chamber half a cm. high.

Stropheodonta reticulata differs distinctly from any other species in the Devonian of Iowa. It resembles *S. pattersoni* Hall of the eastern Devonian but is larger and not nearly so convex as that form. The *S. pattersoni* of Walcott from the Eureka district of Nevada may be the same as this species.

Occurrence.—Confined as far as known to the *profunda* zone of the Cedar Valley limestone at Brandon, Vinton, Linn Junction, and Littleton, Iowa.

Types.—Holotype, M.A.S. 90; paratypes, S.U.I. 6-139, 6-138, 6-137, 6-352, and M.A.S. 290.

STROPHEODONTA UMBONATA
Stainbrook, n. sp.
Plate 33, figures, 6–9, 19

Shell less than medium size; highly concavo-convex; subquadrate in outline with angular cardinal extremities and rounded anterolateral margins, which meet in a gradual curve at the front; a little wider than long, and widest in front of the hinge line. Dimensions of the holotype and of a paratype: length, 20.5 mm. and 22.4 mm.; width, 21.7 mm. and 22 mm. (incomplete); convexity of the pedicle valve, 16.6 mm. and 10.2 mm. Two larger but less convex examples measure 21.9 mm. and 21.6 mm. in length, 24.7 mm. and 24.2 mm. in width, and 10 mm. and 9 mm. in the convexity of the pedicle valve.

Pedicle valve strongly convex, the point of greatest convexity posterior to the midlength, whence the surface slopes rapidly in a broad, even curve to the anterior margin and more rapidly to the lateral margins, depressed a little in front of the cardinal angles; umbo large and conspicuous, projecting beyond the hinge line; beak small, incurving, and projecting a little; cardinal area highest beneath the beak, decreasing in height toward the extremities, gently curved, and situated in the plane of the valve.

Brachial valve strongly concave, the umbonal region flattened or depressed, deepest in the central part, the surface curving upward rapidly near the margins, flattened toward the cardinal angles so as to form small triangular areas elevated above the central part of the valve; beak indistinguishable; area low, flat, and at right angles to the plane of the valve.

Surface of both valves broken by numerous coarse angular radiating costae of variable size, which increase by implantation. The intercostal spaces are as wide as or wider than the costae.

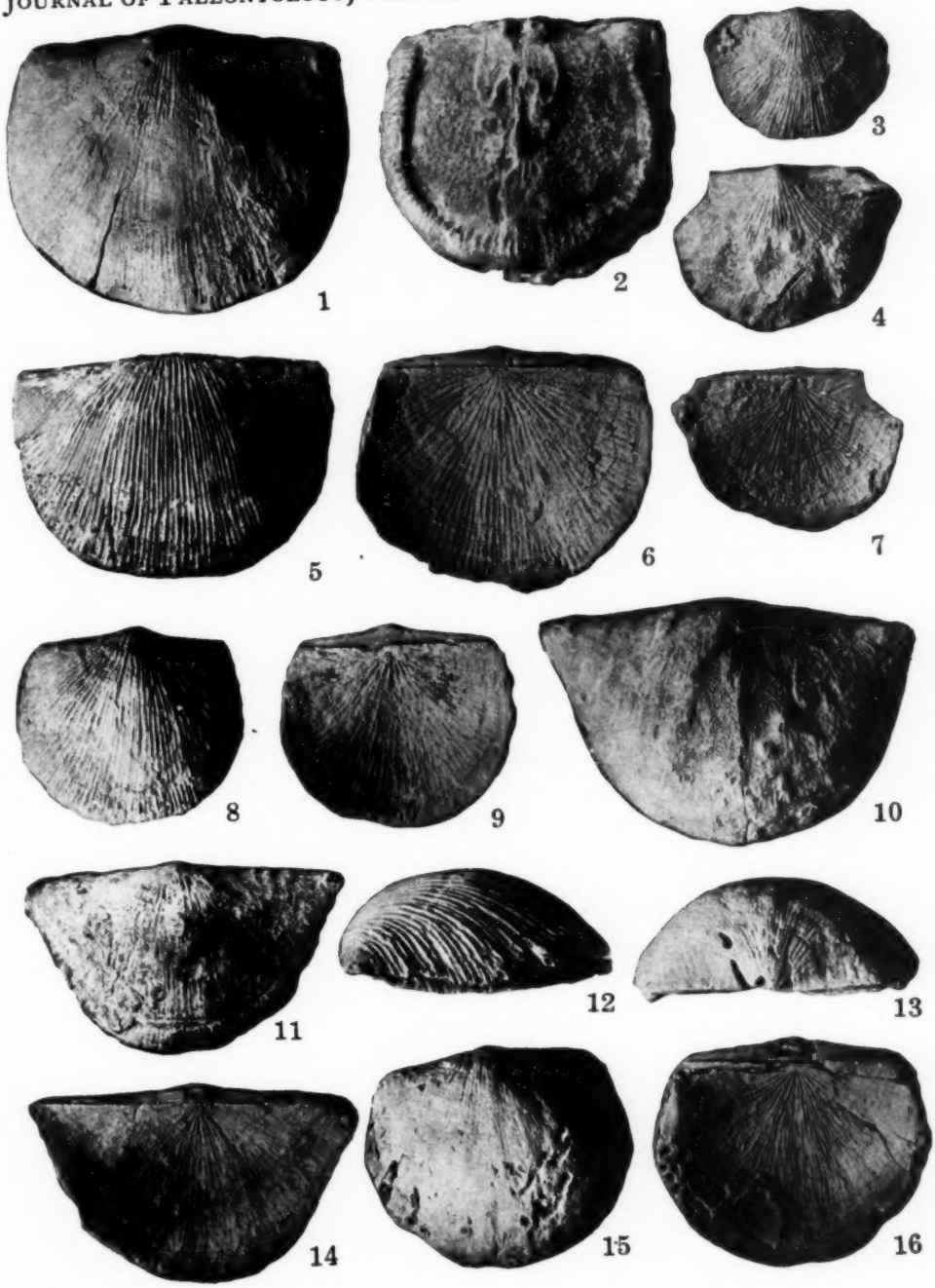
EXPLANATION OF PLATE 34

FIGS. *1, 2, 5, 6, 12—Stropheodonta cedarensis* Stainbrook, n. sp. *1,* Pedicle view of the holotype, S.U.I. 6-363A. *2,* Internal view of a brachial valve, a paratype, M.A.S. 22. *5,* Pedicle view of a slightly crushed paratype, S.U.I. 6-363C. *6, 12,* Brachial and lateral views of a paratype, S.U.I. 6-363B. All from the *waterlooensis* zone at Brandon, Iowa. (p. 247)

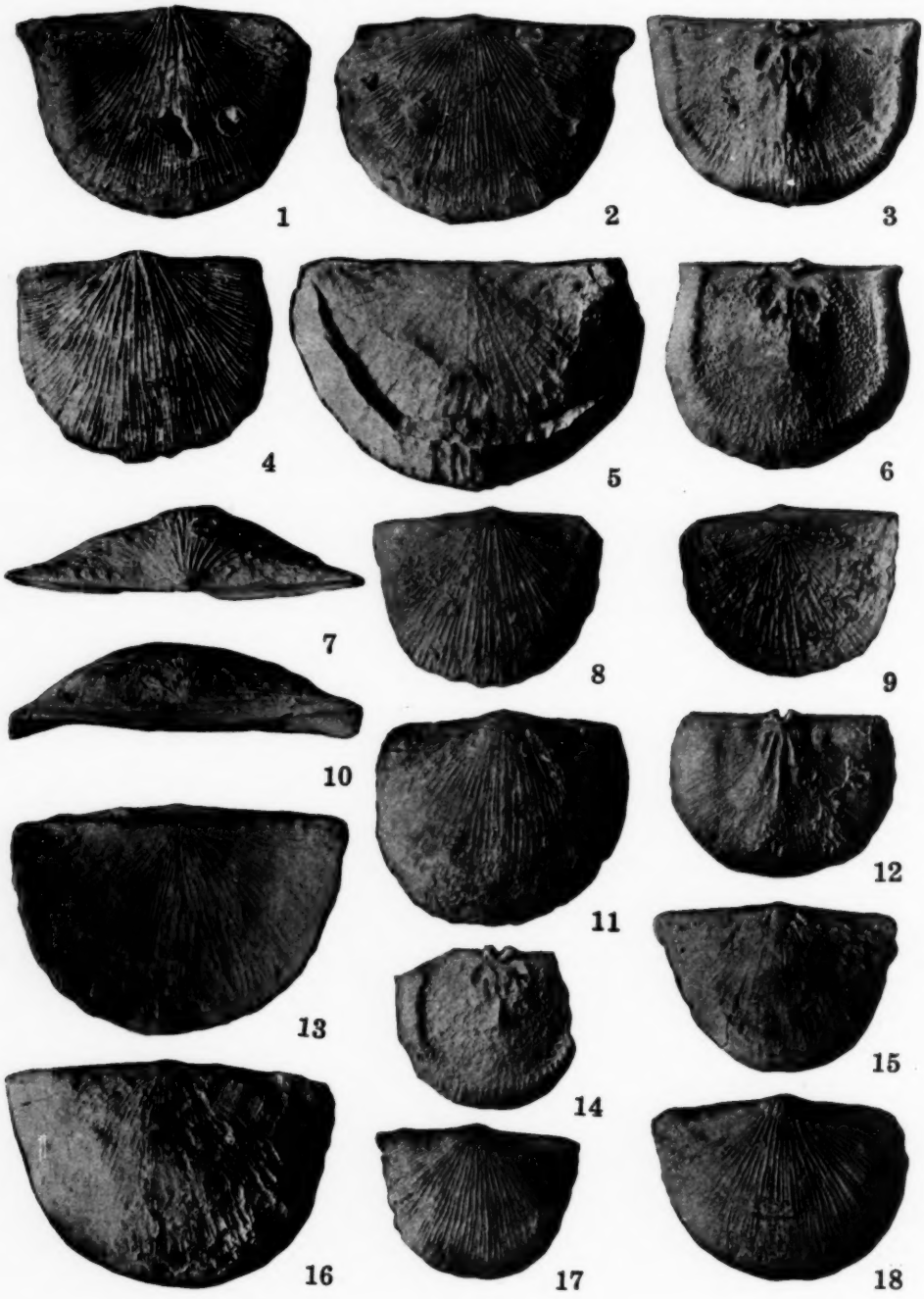
3, 4, 7—Stropheodonta iowensis Owen. *3,* Pedicle view of a hypotype, S.U.I. 6-383. *4, 7,* Pedicle and brachial views of another, M.A.S. 2; both from Buffalo, Iowa. (p. 250)

8, 9, 13, 15, 16—Stropheodonta dorsata Stainbrook, n. sp. *8, 9,* Pedicle and brachial views of a paratype. *13, 15, 16,* Posterior, pedicle and brachial views of the holotype, S.U.I. 6-352A. Both specimens from Brandon, Iowa. (p. 254)

10, 11, 14—Stropheodonta littletonensis Stainbrook, n. sp. *10,* Pedicle view of the holotype, S.U.I. 6-372A. *11, 14,* Pedicle and brachial views of a paratype, S.U.I. 6-372; both are from Littleton, Iowa. (p. 253)



Stainbrook, Devonian Brachiopods



Stainbrook, Devonian Brachiopods

Shell substance when worn is punctate and striate. Occasional growth lines cross the costae.

Occurrence.—Cedar Valley limestone. The type specimens are from the *bellula* zone (*Megistocrinus* beds of Calvin) and were collected at exposures along Rapid Creek in Johnson County between Solon and the Iowa River. Other examples have been found at Linder's boathouse, north of Iowa City, at Buffalo, and at Brandon, Iowa.

Types.—Holotype, S.U.I. 6-350A; paratypes, 6-250B and C, and M.A.S. 475, 486, and 27.

STROPHEODONTA LITTLETONENSIS
Stainbrook, n. sp.
Plate 34, figures 10, 11, 14;
Plate 35, figure 7

Shell greater than medium size, subelliptical in outline with extended cardinal angles and rounded anterolateral margins, wider than long, with the greatest width along the hinge line. Measurements of the holotype and of three paratypes: length, 29.3 mm., 33.2 mm., 28.8 mm., and 23.8 mm.; width, 45.1 mm., 51 mm., 45.4 mm., and 40.7 mm.; convexity of pedicle valve, 10.7 mm., 12.2 mm., 11.7 mm., and 11.1 mm.

Pedicle valve strongly convex, highest at the midpoint, whence the surface curves strongly to the margins, depressed toward the cardinal angles, which are concave along the lateral margin; beak small, projecting a little; area highest beneath the beak, decreasing in height toward the angles, flat or slightly concave, vertically striated, and situated in the plane of the valve. Interior not known.

Brachial valve deeply concave, the surface curving rapidly from the hinge line forward, then gently to the central part of the valve, thence upward with gentle slope to the lateral and anterior margins; the portion of the valve between the cardinal and lateral margins is somewhat concave and a little elevated above the remainder; area about half as high as the opposite area and meeting it at a right angle. Internal characters similar to those of the brachial valve of *Stropheodonta halli*.

The surface of the valves of well preserved specimens is broken irregularly by scattered shallow depressions and is marked by numerous medium-sized rather angular costae, which increase by implantation on the pedicle valve and by division on the brachial. They are separated by depressions as wide as the costae or wider and are crossed by

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EXPLANATION OF PLATE 35

FIGS. *1–3—Stropheodonta halli* Cleland. *1, 2,* Pedicle views of two hypotypes, M.A.S. 772, from Buffalo, Iowa. *3,* Internal view of a brachial valve, S.U.I. 6-367, from Linwood, Iowa. (p. 243)

4, 6—Stropheodonta demissa Hall. *4,* Pedicle view of a specimen. *6,* Interior view of a brachial valve. Both from New York and introduced for comparison with *S. halli*. (p. 243)

5—Stropheodonta reticulata Stainbrook, n. sp. View of an incomplete specimen, the holotype, M.A.S. 90, from Brandon, Iowa. (p. 251)

7—Stropheodonta littletonensis Stainbrook, n. sp. Posterior view of a paratype from Littleton, Iowa. (p. 253)

8, 9, 11, 12—Stropheodonta randalia Stainbrook, n. sp. *8, 9,* Pedicle and brachial views of the holotype, S.U.I. 6-380A. *11,* Pedicle view of a paratype, M.A.S. 184. *12,* Internal view of a brachial valve. All from the abandoned railroad grade east of Randalia, Iowa. (p. 250)

10, 13, 16—Stropheodonta linderi Stainbrook n. sp. Posterior, brachial and pedicle views of the holotype, M.A.S. 28, Linder's boathouse, north of Iowa City, Iowa. (p. 256)

14, 15, 17, 18—Stropheodonta subdemissa Hall. *14,* Internal view of a brachial valve, M.A.S. *11,* from Linn Junction, Iowa. *15, 17, 18,* Pedicle views, of three hypotypes; M.A.S. 321 from Independence, 319 from Shellsburg, 320 from Benton City, Iowa. (p. 246)

numerous fine concentric striae and a few strong lines of growth.

Stropheodonta littletonensis differs from *S. cedarensis* in these ways: it does not attain the size of that species, is more convex, is wider in proportion to length, the cardinal extremities are more extended, and the greatest width is always along the hinge line. The same characteristics will also separate this species from *S. halli*.

Occurrence.—This species occurs in the lower part of the *waterlooensis* zone of the Cedar Valley limestone at Littleton and Brandon, Iowa.

Types.—Holotype, S.U.I. 6-372A; paratypes, S.U.I. 6-372, 6-358, and M.A.S. 1.

STROPHEODONTA QUADRATELLA
Stainbrook, n. sp.

Plate 33, figures 10–14

Shell strongly convex, less than medium size on the average, subquadrate in outline with gently rounded or nearly straight lateral margins and slightly convex front margin; hinge line shorter than the greatest width, which is anterior to the midlength. Dimensions of the holotype and of two paratypes: length, 17.4 mm., 17 mm., and 21.2 mm.; width, 19.1 mm., 18.6 mm., and 22.3 mm.; convexity of the pedicle valve, 8.8 mm., 8.6 mm., and 8.6 mm.

Pedicle valve strongly convex, highest at the midlength or a little posterior, strongly and regularly arched from beak to front, in some specimens more strongly so over the beak; surface flattened or slightly depressed along the midline, curving strongly to the front, abruptly to the lateral margins, and slightly concave at the cardinal angles; umbo weakly developed in most specimens, in some prominent; beak small, slightly projecting; area low, of nearly the same height throughout its length, slightly curved, vertically striated, showing little or no signs of a deltidium, and inclined to the plane of the valve. Interior as in typical forms of the genus.

Brachial valve gently concave, flattened in the umbonal region; area nearly as high as that of the opposite valve and making a right angle with it.

Costae of both valves variable in size, numerous, crowded, strong, narrow, angular, larger on the posterior part of the valves, increasing by division, occasionally by intercalation, and tending to be fasciculate. Growth lines occasionally prominent.

Stropheodonta quadratella resembles *S. plicata* Hall in general appearance and in the grouping of the costae, but differs from that form in the outline of the shell, in the shortness of the hinge line in comparison with the greatest width of the shell, in the less prominence of the umbo, in the flattening of the pedicle valve along the midline, and in its different shape. Our form may be distinguished from *S. costata* by larger size, different shape of the pedicle valve, and different appearance of the costae.

Occurrence.—In the *waterlooensis* zone of the Cedar Valley limestone. Abandoned railway cut and dump east of Randalia, Iowa.

Types.—Holotype, M.A.S. 182A; paratypes, 182.

STROPHEODONTA DORSATA
Stainbrook, n. sp.

Plate 34, figures 8, 9, 13, 15, 16

Shell of medium size, wider than long, with the greatest width anterior to the hinge line, subquadrate in outline, slightly rounded at the angles and broadly rounded at the front. Measurements of the holotype and of two paratypes: length, 27.5 mm., 30.1 mm., and 32.6 mm.; width, 31.5 mm., 37.2 mm., and 37.8 mm.; convexity of the pedicle valve, 11.6 mm., 13.3 mm., and 14.5 mm.

Pedicle valve strongly convex, the surface curving from the central point of the valve with equal rapidity to the margins, slightly auriculate at the angles; umbo a little convex; beak small and projecting a short distance beyond the

hinge line; area flat, of nearly the same height throughout, and situated in the plane of the valve. Interior unknown.

Brachial valve deeply and evenly concave, but flattened in the umbonal region; area low and nearly at right angles to that of the pedicle valve.

Costae of both valves numerous, radiating, coarse, rounded to angular at the summits, and increasing by imbrication on the pedicle valve and by division on the brachial. Growth lines not uncommon and in many specimens conspicuous near the anterior margin.

Specimens at hand are noticeably lacking in costae, due in general to weathering but in some instances due to wear before entombment. The shells are usually reddish or purplish. The medium size, the proportionately greater convexity, and the thickness of the shells distinguish this species from *S. halli*, from *S. cedarensis*, and *S. littletonensis*.

Occurrence.—Our specimens were obtained from the *waterlooensis* zone of the Cedar Valley limestone, chiefly the lower part. The type specimens are from Brandon but others have been collected at Shellsburg.

Types.—Holotype, S.U.I. 6-352A; paratypes, S.U.I. 6-352 and M.A.S. 99.

STROPHEODONTA OCCIDENS (Hall)

Plate 33, figure 21

Tropidoleptus occidens HALL, *1860*, New York State Cab., 13th Ann. Rept. p. 91.—HALL, *1867*, New York Geol. Survey, Paleontology, vol. 4, p. 408, pl. 61A, figs. 50–52.—HALL and CLARKE, *1895*, New York Geol. Survey, Paleontology, vol. 8, pt. II, pl. 82, figs. 37, 38.

Two examples of this little-known species are at hand. They are enclosed in blocks of tough limestone and have been only partly extricated. They measure 8.5 mm. and 8.1 mm. in length and 10 mm. and 11 mm. in width, respectively. Their plications are simple, strong, and angular. Few other characters can be made out. The form does not seem, however, to be a *Tropidoleptus* and is placed tentatively with *Stropheodonta*.

Occurrence.—*Cranaena iowensis* zone of the Cedar Valley limestone.

Types.—Hypotypes, M.A.S. 498.

STROPHEODONTA SOLONENSIS Stainbrook, n. sp.

Plate 33, figures 22–24

Shell small, wider than long, broadest alone the hinge line or a little in front of it, subquadrate in outline with rounded anterolateral margins and nearly straight front and subparallel lateral margins, angles slightly extended. Measurements of the holotype and of two paratypes: length, 11.7 mm., 11.7 mm., and 13.7 mm., and 13.2 mm.; width, 15.4 mm., 17.5 mm., and 17.1 mm.; convexity of the pedicle valves, 5.3 mm., 5.3 mm., and 4.3 mm.

Pedicle valve moderately convex, highest anterior to the midlength, the surface descending with gentle slope to the hinge line and more rapidly to the anterior and lateral margins, more or less flattened in the region of the umbo, and slightly convex in front of the angles. Beak small, slightly projecting; area flat, gently inclined to the plane of the valve, and of nearly the same height throughout to the angles. Exterior marked by numerous fine sharply angular costae, increasing by intercalation, and arranged in three sets, of which the primary set extends to the beak. Intercostal spaces broad and flat, three to four times as wide as one costa and marked by fine radial striae.

Brachial valve moderately concave, flattened in the umbonal region, curving abruptly upward toward the anterior and lateral margins. External markings as in the pedicle valve.

The narrower, more widely spaced costae and the different shape and thinness of the shell distinguish this species from *Stropheodonta costata*, with which it occurs.

Occurrence.—*Independensis* zone of the Cedar Valley limestone at Solon and Shellsburg, Iowa.

Types.—Holotype and paratypes, M. A.S. 224A and 224.

STROPHEODONTA LINDERI
Stainbrook, n. sp.
Plate 35, figures 10, 13, 16

Shell above medium size, strongly concavo-convex, wider than long, with the greatest width along the hinge line, semioval in outline, with the lateral and front margins merging in a broad curve. Dimensions of the holotype: length, 30.6 mm.; width, 44.8 mm.; convexity of the pedicle valve, 10.9 mm.

Pedicle valve evenly arched from beak to front, highest at the central part of the valve, the surface curving thence with moderate rapidity to the anterior and lateral margins and more gently to the cardinal margin, depressed in front of the cardinal angles; umbonal region low and broadly convex; area highest beneath the beak, gradually becoming lower toward the extremities, gently curved, and a little inclined to the plane of the valve.

Brachial valve rather deeply concave, the surface flattened centrally but curving with moderate rapidity upward near the anterior and lateral margins; area flat, more than half as high as the opposite area and making a right angle with it. The internal features of this valve are similar to those of the genotype, but the scars are strongly expressed and elevated.

Surface of both valves broken by numerous fine regular costae, which increase by division and intercalation. About three or four occupy the space of 2 mm. near the midpoint of the pedicle valve. Growth lines not uncommon and usually prominent.

Stropheodonta linderi differs from *S. cedarensis* of the same zone in being wider in proportion to length, in having the greatest width along the hinge line, in having the finer costae closer together, in not attaining as large a size, and in having, as viewed from behind, the lateral and anterior margins projecting below the cardinal margin. The proportionately greater width and distinct shape readily distinguish this form from *S. halli.*

Occurrence.—This species occurs in the southern equivalent of the *waterlooensis* zone of the Cedar Valley limestone and takes the place of *S. cedarensis,* which is distinctive of the zone farther north. It has been collected chiefly in the exposures along Rapid Creek and at Linder's boathouse in Johnson County, Iowa.

Types.—Holotype, M.A.S. 28; paratypes, M.A.S. 185.

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NEW CHONETIDAE AND PRODUCTIDAE FROM PENNSYLVANIAN AND PERMIAN STRATA OF NORTH-CENTRAL TEXAS

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ABSTRACT

The 17 new brachiopods described and figured represent the genera *Chonetes, Chonetina, Lissochonetes, Mesolobus, Paeckelmannia, Dictyoclostus, Juresania, Marginifera, Heteralosia* (n. gen.), *Overtonia, Linoproductus,* and *Cancrinella.*

The Chonetidae constitute one of the most abundant groups of organisms comprising the varied and well-preserved fossil fauna in the Pennsylvanian and early Permian strata in the Brazos and Colorado valleys of north-central Texas. Representatives of the family occur throughout the section and have been found at nearly every locality where fossils have been collected. Their comparatively complex structure tended to promote rapid evolution and consequently limited vertical range. Hence they are useful zone markers. In addition, their geographical distribution is so extensive that they can be used in making correlations almost anywhere in the mid-continent area.

Only in recent years have American paleontologists begun to divide the group into its finer recognizable subdivisions, and the process is not yet complete. Dunbar and Condra (1) made the first notable advance, adding two new genera and about nine new forms deserving varietal or specific rank. Their work has been followed rather closely in this paper, but with some hesitation in respect to the genus *Chonetina*. The forms referred to that genus by Dunbar and Condra constitute a compact phylogenetic unit, as deserving of a generic name as any group in the family, perhaps, but their right to that particular name is questionable, inasmuch as only one species, *C. verneuiliana* (Norwood and Pratten), bears any marked resemblance to the genotype. However, these and related forms are provisionally referred to *Chonetina* for want of definite evidence that they are distinct. Without specimens of the genotype for comparison there is not sufficient justification for establishing a new genus.

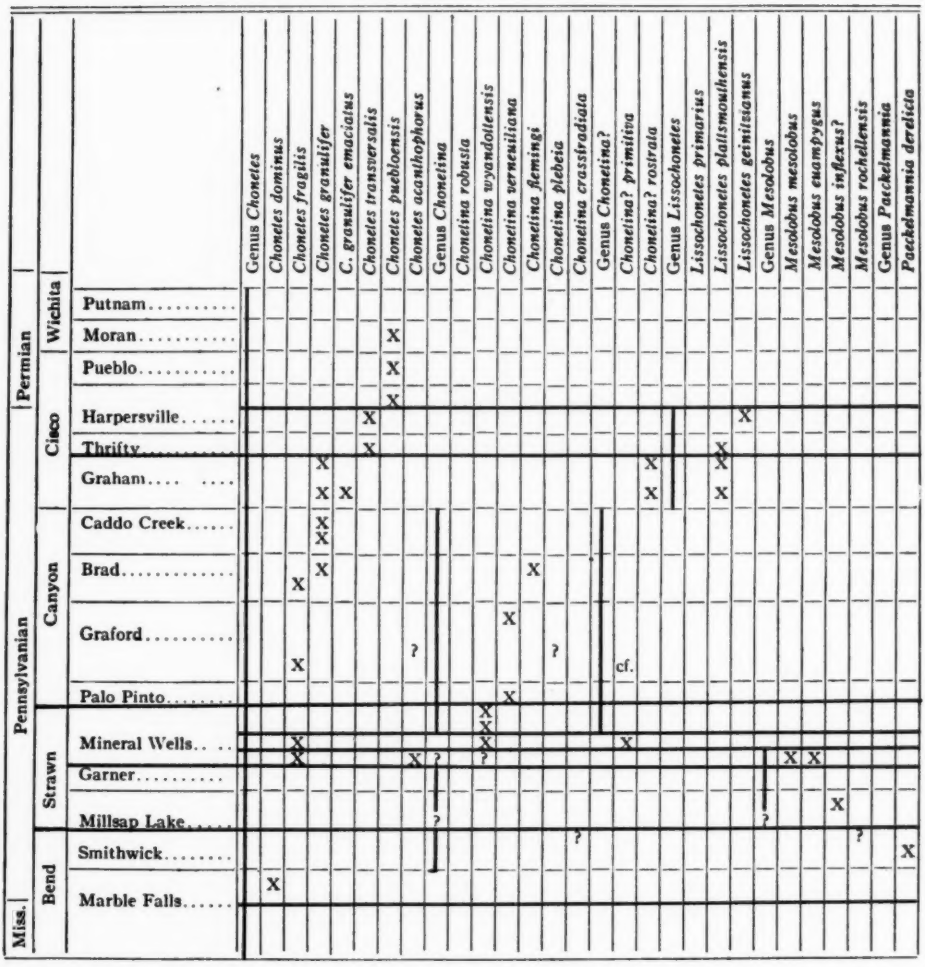
Chonetina? rostrata Dunbar and Condra and *Chonetina(?) primitiva* King, n. sp., might well have been referred to a new genus or subgenus, but again uncertainty as to the true nature of *Chonetina* has been the restraining influence.

The contention of Weller and McGehee (2) that *Mesolobus mesolobus* (Norwood and Pratten) is a smooth rather than a lirate form was verified with the aid of Dr. Dunbar, the specimens examined being topotypes in the collection of Dr. J. Brookes Knight.

The accompanying range table is as complete as the condition of the collections will permit. Specimens of most of the established species have been compared with Dunbar and Condra's types and some specimens were identified by Dr. Dunbar. Dr. Newell identified specimens of *Chonetina wyandottensis* Newell. The new species introduced are distinct and recognizable in Texas and some are found also in Kansas. These latter were known to Dunbar and Condra, who refrained from describing them because they were in doubt as to whether or not the geographic distribution was sufficient to warrant their introduction as new species.

Most of the hitherto undescribed species of Productidae of north-central

Stratigraphic range of Chonetidae of north-central Texas



Questionably identified specimens have been omitted. The symbol ? refers to stratigraphic position rather than identification. Horizontal heavy rules represent unconformities; vertical, range of the genus.

Texas appear to have only local geographic distribution. However, unless a species has been named and carefully described so that paleontologists can recognize it, it is not possible to say definitely that it is limited to a particular area. The distribution of a well known species cannot be known until all strata in which it is likely to occur have been carefully examined, which is usually a task beyond the capabilities of any one individual. The fact that a species has not been previously described is good evidence that it is not common in areas that have been examined, but it is not conclusive proof that it is unrepresented. In areas that have received only superficial study it may be abundant. It is unsafe, therefore, to state that the distribution of an undescribed species is limited to a certain area.

If the geographic distribution of a

species can be determined, together with the nature of the strata in which the form occurs, the factors governing the distribution can be more accurately postulated. The complex whole of the environmental causes of restricted geographic range cannot be inferred from a partial summation of the effects. The ecologic factors active at present should not be assumed to have been active in the past with identical results unless substantiated with geologic evidence. On the contrary, the factors governing the range of a fossil species should be determined from contemporary evidence, supported as much as possible by current events. For purposes of paleo-ecology, therefore, a species of limited distribution is more valuable than one of unknown geographic range, although it has, perhaps, less practical utility.

SYSTEMATIC DESCRIPTIONS

Class BRACHIOPODA Cuvier, 1802

Order PROTREMATA Beecher, 1891

Family CHONETIDAE Hall and Clarke, 1893

Genus CHONETES Fischer, 1837

CHONETES DOMINUS King, n. sp.

Plate 36, figures 1–7

Individuals belonging to this species are subquadrate in outline. The anterior margin may be broadly curved or sinuate but is nearly straight across the median two-thirds of the shell and rounds sharply into the straight parallel lateral margins. A slight constriction of the lateral margins just in front of the hinge line gives the extremities the appearance of being somewhat extended, but the length of the hinge line does not exceed the greatest width of the rest of the shell by more than 1 mm. and may not equal it. The posterior margins meet at an angle of about 170° at the beak.

Most individuals are almost imperceptibly sinuate but some specimens have a distinct sinus on the anterior third of the shell. Some shells that have a prominent sinus in the early stages appear to be crushed specimens. The umbo is very broad and low, scarcely differentiated from the rest of the shell. The posterolateral concave slope is bordered by the indistinct lateral humps and the posterior one-third or one-half of the lateral margins. The longitudinal curvature of the shell is uniform or slightly flattened on the umbo. The transverse curvature at mid-length is only slightly flattened medially and, although it is not so sharp as the longitudinal curve, it has a smaller radius than is common among species of the genus *Chonetes*. The shells are therefore deep, some specimens being nearly a fourth as deep as wide.

Uncrushed dorsal valves are very rare. They are evenly concave longitudinally, but nearly flat. Transversely they are slightly concave near the lateral margins except on the posterior third, which is flat or nearly so. Just in front of the hinge line the lateral margins are depressed, the concavity thus formed coinciding with the constrictions in the lateral margins of the ventral valve.

Faintly lamellose growth lines are prominent near the anterior margin of both valves, but are somewhat less conspicuous on the lateral margins, where they are more closely spaced. The entire surface of both valves is sculptured with fine closely spaced rounded radial lirae, of which about 5 or 6 occupy a space of 1 mm. near the margins. The number of lirae is increased by intercalation and by splitting.

There are about 11 spines on the posterior margin on each side of the beak. The cardinal area of each valve is noticeably striate longitudinally, the ventral more so than the dorsal, but transverse striae are visible only at high magnification.

The ventral median septum rises sharply just ahead of the beak, with an anteriorly directed point, and then declines rapidly and continues as a low ridge to a point just in front of the mid-length. The rounded lateral ridges are

parallel and extend from the anterior end of the adductor muscle scars to a point just beyond the mid-length of the valve. These ridges and the septum end at the same line. Papillae cover the valve surface except the muscle scars, and are especially abundant and closely spaced near the margins. The largest ones are at the anterior end of the septum.

In the dorsal valve the thickened border of the visceral disc rounds into the ends of the crura, which are separated under the cardinal process by a small pit. On the median third of the shell the median septum forms a low triangle, which rises rapidly from the low posterior portion. The lateral ridges diverge at an angle of about 30° and extend across the posterior third of the shell.

Dimensions (in millimeters) and proportions of four specimens:

Width	Length	Thickness	L/W	T/W
20.3	14.0	4.6	.69	.23
18.8	12.2	4.1	.65	.22
16.9	11.3	3.4	.67	.20
14.7	10.0	3.0	.68	.20

Chonetes multicosta Winchell has a somewhat similar outline but is markedly umbonate. No other form known to the writer bears enough resemblance to *C. dominus* to necessitate comparison.

This species has thus far been found only in black shale partings near the top of the Marble Falls limestone, where it is locally very abundant.

Syntypes.—Bureau of Economic Geology nos. K-260, K-261, K-262, K-263, K-267, K-268, K-271, K-272, K-273, K-274, K-275, K-276, a total of 276 specimens and 33 free ventral and 10 free dorsal valves in addition, from the Marble Falls limestone exposed in a cut on the Llano road near the top of a hill 2.7 miles south of San Saba, San Saba County, Texas.

CHONETES FRAGILIS King, n. sp.
Plate 36, figures 8–13

Chonetes granulifer Owen. PLUMMER and MOORE, *1921*, Univ. Texas Bull. 2132, pl. 13, figs. 19–20.

Chonetes fragilis has a broadly rounded anterior margin, which rounds more sharply into the nearly straight lateral margins. The latter are commonly very slightly concave just in front of the posterior margin, the cardinal extremities being very slightly extended. The lateral margins converge anteriorly at an angle of 35° or less; on most specimens the angle is between 25° and 30°. On a very few individuals the sides are almost parallel. The shape varies, therefore, from arcuate to subquadrate, but neither of these extremities is well represented. The posterior margins meet at an angle of about 172°.

The ventral valve has a low, broad umbo, which is scarcely set off from the rest of the shell. The posterolateral surfaces are very broadly concave. A very few specimens have an almost imperceptible sinus amounting to little more than a flattening of the anterior median portion of the shell. The longitudinal curvature decreases regularly anteriorly, the greatest thickness being back of mid-length. The transverse profile at mid-length is a broad, even curve, somewhat flattened medially on the most convex specimens.

The curvature of the dorsal valve follows that of the ventral. The concavity gradually decreases anteriorly, and transversely is almost regular. The lateral margins are slightly depressed just in front of the hinge line, corresponding to the constrictions of the margin of the ventral valve. In front of this depression the margins are elevated slightly above the plane including the posterior and anterior margins.

There are about seven spines on each side of the beak, diverging from the posterior margin at an angle of about 35°. The ventral cardinal area is very narrow, scarcely wider than the dorsal. Extremely faint radial lirae cover the surface of both valves except very narrow areas along the posterior margin. About nine occupy a space of 2 mm. at the margin. Around the outer one-fourth or one-third of the shell faint growth lines are visible.

Within the dorsal valve the crura are short, broad, and low, and limit deep dental sockets. The visceral disc is not sharply set off, but a faint ridge extends the ends of the crura to the lateral margins. Under the cardinal process is a triangular pit with thickened margins. The lateral ridges diverge from the posterior angles of this pit, forming with its thickened border a distinct **M**. They are short and diverge at an angle of about 45°. The median septum has a long posterior but an abrupt anterior slope, and extends only to the mid-length of the valve. Small round papillae cover the marginal third of the valve. They increase in number and decrease in size toward the margin, and are arranged in distinct radial rows. The ventral interior has not been observed.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
17.8	11.6	3.2	.65	.18
17.3	10.0	3.3	.58	.19
16.3	9.8	2.5	.60	.15
15.8	9.9	2.8	.63	.18
14.9	9.5	2.6	.64	.18

Chonetes fragilis is much less convex than any other species except *C. granulifer* var. *emaciatus* King, n. var. and *C. dominus* King n. sp. The latter has a very different longitudinal profile and is subquadrate and sinuate; it is therefore readily distinguishable. *C. granulifer* var. *emaciatus* most closely resembles *C. fragilis* but is somewhat smaller and more arcuate in outline, and its lirae are fine and widely spaced rather than low and broad with very narrow interspaces. *C. granulifer* Owen, s.s., is much more convex, with a strong umbo and sinus, and most specimens are longer than *C. fragilis*. In the Brad formation, however, the specimens of *C. fragilis* are more convex than in lower formations, and there seems to be some intergradation with *C. granulifer*, which makes its first appearance in the Brad. *C. transversalis* Dunbar and Condra and its descendants are so much more transverse and convex than *C. fragilis* that comparison is scarcely necessary. The interior of the dorsal valve of *C. transversalis* is, however, remarkably like that of *C. fragilis*. The small, extremely convex, sinuate *Chonetes acanthophorus* Girty (3) does not require comparison.

C. fragilis is abundant in the East Mountain shale member of the Mineral Wells formation in the vicinity of Mineral Wells, and occurs in the Graford and Brad formations, apparently grading into *C. granulifer* in the latter.

Syntypes.—Bureau of Economic Geology nos. K-709 (from the East Mountain shale member of the Mineral Wells formation in the bluff west of the cemetery at Mineral Wells, Palo Pinto County, Texas, 29 individuals) and P-4477 (from the same member exposed in the clay pit at Mineral Wells, 21 individuals and one free dorsal valve).

CHONETES GRANULIFER Owen var. EMACIATUS King, n. var.

Plate 36, figures 14–18

In calcareous sediments the typical form of *C. granulifer* Owen is a long, narrow subquadrate shell, markedly convex in profile. In intervening arenaceous or argillaceous strata only a few feet or even a few inches thick it is transverse with a subarcuate margin, and has a very low convexity(3a). This latter form must be regarded as an ecologic variant and should not be afforded unwarranted stratigraphic value.

As previously stated, this variant is transverse, with only slight convexity. The anterior margin is rounded, and almost regularly rounded into the nearly straight lateral margins, giving the shell a subarcuate form. The cardinal extremities are very slightly extended on a few specimens, which makes the lateral margins very gently concave in their posterior portion. Commonly the extremities are not extended. The median angle of the posterior margin is 170° to 175°.

The umbo is small and narrow, scarcely extending beyond the hinge line, but it is sharply delimited for about 2 mm. by almost vertical lateral slopes,

which form an umbonal angle of 80° to 90°. It loses definition back of the mid-length and passes into the regular curvature of the valve. The posterolateral slopes are very broadly concave. There is no trace of a sinus on any of the uncrushed specimens observed. The longitudinal curvature is regular, the greatest thickness being at mid-length. The transverse profile at mid-length is flattened on the lateral slopes and evenly convex over the median third of the valve.

The dorsal valve is gently and evenly concave except posterolaterally where it is transversely flattened, and just before the beak, where there is a deeper depression corresponding to the ventral umbo.

About six fine spines diverge from each side of the posterior margin at an angle of about 40°. The surface of both valves is covered with fine, rather sharply rounded radial lirae, of which about 4 or 5 occupy a space of 1 mm. They are, however, almost imperceptible on the posterolateral surfaces. They increase by splitting and are very prominent on most specimens. Faint growth lines are visible on the anterior third of the shell.

The shell substance is very thin and light, so the muscle scars are not deeply impressed. They seem to follow the pattern of *C. granulifer* Owen. The papillae are finer and somewhat more obviously radial in arrangement. The visceral disc, except for a narrow longitudinal median band, has no papillae.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	L/W
6.8	3.6	1.3	.53	.19
9.0	5.5	1.3	.61	.15
12.2	6.8	1.5	.56	.12
13.4	8.1	1.6	.60	.12
16.5	8.4	2.3	.51	.14

This form resembles *C. fragilis* King n. sp. but has more arcuate margin and the radial lirae are much more prominent on most specimens. Its maximum size is somewhat less than that of *C. fragilis*. It also resembles *C. transversalis* Dunbar and Condra, but it is somewhat smaller and less transverse and is also less convex and thinner than that species. It scarcely resembles *C. granulifer* Owen, s.s., which is a longer, heavier, more nearly quadrate shell with a more prominent umbo. *C. granulifer*, s.s. did, however, develop out of such a shell, as is shown by the growth lines. They indicate a transverse juvenile stage from which the subquadrate shape was developed by disproportionately rapid growth at the anterior margin.

C. granulifer var. *emaciatus* has thus far been found only in the South Bend shale member of the Graham formation.

Syntypes.—Bureau of Economic Geology no. K-192, from the South Bend shale member of the Graham formation in a low bluff on the old Jacksboro road 2.2 miles east of Bryson, Jack County, Texas, 39 individuals and one free ventral valve.

CHONETES PUEBLOENSIS King, n. sp.

Plate 37, figures 1–6

Chonetes meekianus Girty. PLUMMER and MOORE, *1921*, Univ. Texas Bull. 2132, pl. 24, figs. 2–5.

This is a large alate species of moderate convexity. The anterior margin is very gently curved except on strongly sinuate specimens, which have a slightly sinuate margin. The anterolateral margins are only a little more abruptly rounded into the rapidly converging lateral margins, which are concave posteriorly but become convex at the mid-length of the shell. The lateral margins converge at an angle of 40° to 60°, but on most specimens the size of the angle is less than 50°. The posterior margin is almost straight, the angle at the beak being about 175°.

The sinus is extremely faint to imperceptible on all but about one-tenth of the specimens, which have a distinct but very broad and shallow depression, which appears at a point behind the mid-length of the shell but in front of the umbo. The umbo itself is small and low but sharp, and distinctly set off from the rest of the shell. Its sides for 2 or 3 mm. in front of the posterior margin slope steeply to the nearly flat posterolateral

surfaces and diverge at an angle of about 98°, but lose definition in the regular curvature of the valve. Near the lateral margins just back of the mid-length of the shell the posterolateral surfaces are broadly concave and round evenly to the central portion of the valve. The longitudinal curvature is uniform. The transverse profile at mid-length is broadly and evenly rounded except medially, where it is almost flat.

The dorsal valve is gently concave, with a faint dimple corresponding to the umbo. For about 3 mm. a small triangular area is sharply depressed below the valve surface, the sides meeting posteriorly at a 98° angle. The anterior side of the triangle is absorbed by the general concavity of the valve. There is a slight depression of the lateral margins just before the hinge line. The lateral and anterior valve margins lie in a plane; the posterior margin rises medially slightly above the others. The median fold is indistinguishable except on the few strongly sinuate specimens.

There are 11 or 12 spines on each side of the beak. They diverge at an angle of about 40° from the posterior margin. Striae are visible on both the cardinal areas. The dorsal area is somewhat wider medially than at the extremities. The surface of both valves is covered with low rounded lirae, of which about 4 occupy a space of 1 mm. They increase by splitting. Faint and sparse growth lines are visible on the anterior third of the shell.

The hinge teeth are strong, extending nearly 1 mm. in front of the hinge line and about 2.5 mm along it. The median septum is small; it is not as large as one of the hinge teeth in any dimension. It appears to have had a rudimentary anteriorly directed spine. The lateral ridges are low and poorly defined. They arise at the anterior end of the adductor muscle scars and extend over the median third of the valve. Low rounded papillae cover the valve surface but are decidedly finer and more closely spaced and are more obviously arranged in radial rows over a distinct narrow zone about 1.5 mm. in width around the edge of the shell.

The crura are broad and short and limit large dental sockets. They diverge at an angle of about 140°. The thickened border of the visceral disc is very close to the shell margin and rounds into the posterior side of the crura. The median septum has a gentle posterior but an abrupt anterior slope and extends over two-thirds the length of the valve. The unusually prominent but short lateral ridges diverge at an angle of about 55° to 60°. They are as large as the septum but only about half as long. Papillae cover the anterolateral surfaces and the border is ornamented as in the ventral valve.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
26.2	12.7	4.7	.49	.18
28.4	15.2	5.2	.54	.18
26.5	14.8	5.6	.56	.21
26.1	14.8	4.0	.57	.15
25.8	13.6	4.2	.53	.16

C. puebloensis is intermediate between *C. transversalis* Dunbar and Condra and *C. meekianus* Girty both genetically and stratigraphically. It is larger than *C. transversalis* and not quite so alate. Internally the narrow sharply defined border of very fine, regularly arranged papillae seems to be distinctive. It is a smaller, lighter shell than *C. meekianus* and the posterior margins do not form as sharp an angle as in that form. It is also slightly less convex than *C. meekianus*. It is much more transverse than *C. granulifer* Owen, with which it is not likely to be confused.

C. puebloensis is apparently restricted to the Pueblo formation and the strata immediately above and below it. It has been found in this zone from northern McCulloch County to northeastern Callahan County. This is quite probably the form listed by Dunbar and Condra in their range table (1,*a*) as *C.* aff. *meekianus* Girty.

Syntypes.—Bureau of Economic Geology nos. K-352 and K-353 (from Camp

Colorado limestone of Pueblo formation in a cut on the Cisco-Moran road 1 mile north of Pueblo, Callahan County, Texas, 19 individuals and 3 free dorsal valves) K-363 (from Camp Colorado limestone member in a road cut 1.7 miles east of Santa Anna, Coleman County, Texas, 27 individuals and 1 free ventral valve), and P-5773 (from road cut northeast of Randolph College, Cisco, Eastland County, Texas).

Genus CHONETINA Krotow, 1888
CHONETINA? PRIMITIVA
King, n. sp.
Plate 37, figures 7–11

This species is long and narrow, rather large, and nearly quadrate. The anterior margin is very broadly rounded, the anterolateral margins very sharply rounded. The lateral margins are straight or rounded, commonly slightly constricted just in front of the cardinal extremities, which appear somewhat extended as a result. The lateral margins are subparallel on most specimens but may converge or diverge at an angle of as much as 20°. If they converge, the greatest width is at the hinge line; if they diverge, it is in front of the mid-length. Young specimens are more transverse than mature ones. The average length varies from about 0.63 to about 0.68 of the width and the width increases from about 11 mm. to about 19 mm.

The beak is low and prominent and extends a little beyond the posterior margin. From the very earliest stages it is deeply divided by a sharp sinus, which broadens anteriorly. Its sides diverge at an angle of about 40° as prominent sharp humps, flattened laterally, which extend to the anterior margin. The posterolateral areas are broadly concave. The longitudinal curvature is fairly regular but may increase somewhat anteriorly. The evenly rounded transverse profile is interrupted medially by the deep rounded notch of the sinus.

The dorsal valve conforms to the ventral. There is a subtriangular depression on each side of the high, broad fold. The valve margins lie in a plane except for the fold, which is strongly elevated, and the posterior margin, which may be slightly depressed. Specimens having a less strongly elevated fold have depressed anterolateral margins as well.

The cardinal areas are narrow and coarsely striate longitudinally. There are about seven very small spines on each side of the posterior margin. On a specimen with a transparent shell the tubes connecting the spines with the interior are visible and they are situated as in *Chonetes* s.s. These tubes show that there were originally at least nine spines, the innermost of which are no longer discernible. The surface of both valves is covered with rounded radial lirae, which are faint on the umbo and much stronger at the margins. There are commonly nine to eleven in a space of 2 mm. They increase by splitting. The ventral valve of most specimens shows numerous regularly spaced small crescentic fractures in the outer shell layer, where surface spines have been broken away. Growth lines are discernible at early stages but are lamellose and prominent on the anterior one-third or one-fourth of the shell.

This species is obviously closely related to the somewhat younger *C. rostrata* Dunbar and Condra. The growth lines indicate a rather transverse juvenile stage, the long, narrow mature stage being attained by disproportionately rapid growth at the anterior margin. The growth lines on *C. rostrata* show a similar juvenile stage, a long, narrow intermediate stage, and a transverse mature stage arrived at by disproportionately rapid growth at the lateral margins. On *C. primitiva* the sinus and lateral humps continue strong and regularly increasing to the anterior border. On *C. rostrata* they change rather abruptly at mid-length, the sinus becoming rapidly wider and the humps much farther apart and lower. *C. primitiva* is strongly and evenly convex. *C. rostrata* Dunbar and Condra is less convex, being somewhat flattened anteriorly, though strongly convex over the umbo. As previously

stated, the ratio of length to width of *C. primitiva* increases from about 0.63 at 11 mm. width to about 0.68 at 19 mm. width. These figures are averages, the length and width of about 50 specimens having been plotted and a curve drawn through the points. A similar curve for about 40 specimens of *C. rostrata* showed the ratio decreasing from about 0.69 at a width of 7 mm. to about 0.62 at a width of 19 mm. From these data and from the evidence of the growth lines it is concluded that the ancestral stock was a convex, sinuate, rather transverse form, which became long and narrow with strong sinus and lateral humps in *C. primitiva* and then assumed again the transverse form in *C. rostrata*, the sinus and humps declining.

It will be noticed that at a width of about 13 mm. the ratio of length to width is about the same in the two forms. However, the greater convexity of *C. primitiva* and the uniform increase in the width of its sinus with the consequent uniform divergence of its lateral humps, which continue straight and strong to the anterior margin, should distinguish this form from *C. rostrata* even at the stage of growth at which the ratio of length to width is the same.

C. primitiva occurs abundantly in the Salesville shale member of the Mineral Wells formation of the Strawn group. A closely related form from the lowest part of the Graford formation of the Canyon group has a slightly more arcuate margin, and the lateral humps diverge at a slightly greater angle, but the amount of intergradation makes it infeasible to distinguish them. The variant is interesting as an indication of the gradual transition to *C. rostrata* of the Graham formation. Dunbar and Condra's specimens from localities near Ada, Oklahoma, probably belong to *C. primitiva* rather than to *C. rostrata*.

Syntypes.—Bureau of Economic Geology nos. K-3 and K-4, from the Salesville shale member of the Mineral Wells formation on a hillside above the road 3 miles west and 1 mile northwest of the west city limits of Mineral Wells and east of Brazos River, Palo Pinto County, Texas, 52 individuals.

CHONETINA ROBUSTA
King, n. sp.

Plate 37, figures 12–16

Chonetina robusta is a very thick-shelled form, extremely convex, and unusually long in proportion to its width. The gently curving anterior margin rounds rather evenly into the lateral margins, which meet the posterior margin almost at right angles. The outline is subsemielliptical as the length is three-fifths to three-fourths the width. Immature specimens are much more transverse, and their cardinal extremities are extended.

The longitudinal curvature is uniform, the greatest depth of the shell being at mid-length. The transverse curvature at mid-length is somewhat flattened on the lateral flanks and sharply convex over the center, but it is interrupted by the deep, U-shaped sinus. The sinus becomes prominent at an early stage and continues to the anterior margin without greatly increasing either its width or depth, which are subequal throughout. The posterolateral surfaces are markedly concave. The umbo is rather narrow and prominent, extending beyond the hinge line.

The dorsal valve is concave, especially on the posterior portion, which is crushed down into the ventral valve. The median fold is low but prominent on the anterior half of the valve. The valve margins lie in two planes. The anterior and the greater part of the lateral margins lie in one plane except that on each side of the fold the anterior margin is depressed. The posterior margin and about 2.5 to 3 mm. of the posterior portion of the lateral margins lie in the second plane, which meets the first at an angle of about 165°. Some specimens have broad shallow grooves across the lateral margins just in front of the cardinal extremities.

There are eight or nine flat-lying spines on each side of the beak of mature speci-

mens. Smaller specimens have only five or six. The entire surface of both valves is sculptured with coarse rounded lirae, about 4 of which occupy a space of 1 mm. These are strongest on the umbo and weakest along the posterior border on the lateral slopes. On the dorsal valve they are very faint just in front of the cardinal extremities. They increase by splitting. Growth lines are visible over most of the shell but are most prominent near the margins, where they are also most closely spaced.

Small specimens are transverse and alate but growth is disproportionately more rapid at the anterior margin as is shown by the growth lines, so that the shape becomes progressively less transverse. As the convexity is uniform, mature shells are also much thicker in proportion to their width.

Dimensions (in millimeters) and proportions of three specimens:

Width	Length	Thickness	L/W	T/W
14.4	9.1	3.4	.63	.24
15.5	10.2	3.8	.66	.25
16.2	11.9	5.1	.73	.31

Immature specimens of *C. robusta* resembles *C. crassiradiata* Dunbar and Condra but may be distinguished by the deeper U-shaped sinus and stronger umbo. Specimens having a faint sinus can scarcely be differentiated. This would seem to indicate that *C. robusta* was derived from *C. crassiradiata*. Mature shells of the former are much longer in proportion to the width, and also much more convex, but the growth lines show that the most elongate shells were transverse in their early stages. The mature shells resemble *C. flemingi* (Norwood and Pratten) but are much heavier and somewhat longer. The most conspicuous difference, however, is the broader and deeper U-shaped sinus of *C. robusta*. Its radial lirae are more rounded, also, and its lateral margins more nearly parallel. *C. alata* Dunbar and Condra is even more alate than *C. flemingi* and its sinus is shallower. *C. plebeia* Dunbar and Condra is much smaller, with less curvature, and the lirae are much fainter and finer than in *C. robusta*. *C. verneuiliana* (Norwood and Pratten) and *C. wyandottensis* Newell are both very long and narrow with a much narrower umbo than *C. robusta*. The lateral slopes of both are much more strongly concave.

This form has been found at only one locality, where it occurs in association with *Prismopora triangulata* (White), which has not yet been found above the Millsap Lake formation in the Brazos Valley. Its stratigraphic position is probably in the Millsap Lake, but the outcrop is isolated and cannot yet be definitely correlated.

Syntypes.—Bureau of Economic Geology nos. K-132 and K-137, from a creek bed 3½ miles east and 1 mile south of Rochelle, McCulloch County, Texas, 16 individuals and half of a ventral valve.

Genus LISSOCHONETES Dunbar and Condra, 1932

LISSOCHONETES PRIMARIUS King, n. sp.

Plate 38, figures 1–6

This is a large species with a variable outline. It is commonly subquadrate with the cardinal extremities very slightly extended. The anterior margin is nearly straight but may be sinuate or curved, more commonly the latter. The anterolateral margins are sharply rounded and the lateral margins are nearly straight. They are parallel or converge at an angle of as much as 30°. The posterior margin is almost straight on uncrushed specimens, but the convexity is so great that on crushed individuals the median angle is prominent.

The convexity of the ventral valve decreases regularly and rapidly toward the anterior margin, the greatest thickness being, therefore, behind the mid-length. A broad faint sinus begins just in front of the beak and continues to the anterior margin becoming gradually broader, but it is deepest near the mid-length of most specimens. The posterolateral areas are strongly concave. The transverse profile at mid-length is concave medially, convex over the lateral

humps, and straight on the lateral slopes.

The configuration of the dorsal valve conforms to that of the ventral. Two broad shallow depressions corresponding to the lateral humps are separated by a broad low fold which rises just in front of the beak and becomes gradually broader anteriorly. It is strongest near the mid-length. The posterolateral surfaces are gently concave. If the anterolateral margins and the anterior portions of the lateral margins be regarded as forming the plane of the valve margins, the anterior margin rises above this plane and the posterior portions of the lateral margins slope downward from it to the posterior margin, which lies entirely below it.

Seven or eight spines diverge from each side of the posterior margin at an angle of about 45°. On very small specimens there are only five spines on each side of the beak. Very faint growth lines are visible near the anterior margin of most specimens. The entire surface of both valves bears minute pits, which were left by the breaking away of fine surface spines. The cardinal areas are narrow; the dorsal is wider than the ventral medially but narrower at the extremities.

Within the ventral valve the teeth are oblique and curved downward laterally. Their slightly upturned inner points are somewhat thinner than the portion adjoining the valve. A small deltidium with a prominent ridge at its extremity partially fills the delthyrium. Below it the median septum extends anteriorly and then downward in a sharp arc to a point near the posterior end of the adductor muscle scars. It runs forward as an even, rounded ridge to a point well in front of the mid-length of the shell. The visceral area is clearly outlined by a marked thickening of the shell. The inner openings of the cardinal spines appear as two rows of pits about 0.3 mm. from the hinge line at its extremities and extending to the lateral ends of the teeth. The outer two or three openings are visible from a point directly above the valve. The whole interior of the valve except the muscle scars bears low, round papillae in radial rows. They are smallest and most numerous outside the visceral area.

Within the dorsal valve the median septum extends from the anterior end of the adductor muscle scars to the mid-length of the valve as a low narrow triangle, its posterior side much the longer. The visceral disc is set off by a thickening of the shell which forms a low ridge just inside the margin and posteriorly rounds into the ends of the crura from their posterior side. The crura are low and broad, and diverge at an angle of only 140°. This comparatively small divergence of the crura was not mentioned in the description of any other species of *Lissochonetes*. Radial rows of small rounded papillae cover the valve except in the vicinity of the muscle scars.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
17.9	11.1	3.7	.62	.21
16.7	11.0	3.4	.66	.20
13.8	9.0	2.7	.65	.20
10.3	6.9	1.9	.67	.19
8.7	5.8	1.8	.67	.21

L. primarius attains a much larger size than any other American species so far described. *L. plattsmouthensis* Dunbar and Condra is not only smaller but more transverse and more convex and has a much deeper sinus than *L. primarius*. *L. geronticus* Dunbar and Condra is also smaller, more convex, and more strongly sinuate than this species, but no more transverse. *L. senilis* Dunbar and Condra is a longer subquadrate shell, with a fainter sinus. *L. geinitzianus* (Waagen) resembles *L. primarius* in many respects but is less convex and less strongly sinuate. It is the only species likely to be confused with the one here described. However, it occurs much higher in the section.

L. primarius is abundant in the Jacksboro limestone member of the Caddo Creek formation southeast and northeast of Jacksboro, Jack County, Texas.

Syntypes.—Bureau of Economic Geology nos. K-1488, K-1489, and K-1491

(from a shale parting in the Jacksboro limestone in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, 56 individuals and one free dorsal and 11 free ventral valves) and K-1530 (from the Jacksboro limestone on a hillside north of the Chico road, 6.6 miles northeast of Jacksboro, 11 individuals, one free ventral and one free dorsal valve, all small).

Genus MESOLOBUS Dunbar and Condra, 1932

MESOLOBUS ROCHELLENSIS King, n. sp.

Plate 38, figures 7–15

This species is large for the genus and somewhat longer than most species. The anterior margin is very broadly rounded or straight, very rarely sinuate. The anterolateral margins are abruptly rounded into the lateral margins, which are nearly straight. They are commonly parallel but may converge at an angle of as much as 15°. The cardinal extremities may be slightly extended or rounded but on most specimens they form right angles. The posterior margins form an angle of about 160°, but very convex specimens appear even more pointed because of the extension of the umbo beyond the margin.

The sinus, which appears about 2 mm. from the beak, is very deep and narrow and is nearly filled by the sharp median fold. The fold is set off from the higher lateral humps by deep sharply angular grooves, which diverge at an angle of 15°, more or less. The lateral humps are clearly defined on their inner slopes, but the lateral slopes are nearly flat except posteriorly. The umbo is low and broad and not sharply defined, so the posterolateral slopes are gently and evenly concave. The longitudinal curvature is almost uniform, but the greatest thickness is at a point a little back of mid-length, and the umbo is somewhat flattened on some specimens. Transversely the profile at mid-length is broadly rounded or flattened on the lateral slopes and sharply rounded into the angular grooves of the modified sinus. The fold is a little broader than high, and noticeably lower than the lateral humps.

The dorsal valve is deeply concave. The fold rises about 2 mm. in front of the hinge line and becomes gradually higher and broader. However, the sinus in the fold is so broad and deep that the median portion of the valve appears to have two sharply angular plications rather than a sinus within a fold. The sinus is somewhat broader than deep and not so deeply depressed as the lateral areas.

There are about nine spines on each side of the beak, diverging from the posterior margin at an angle of about 65°. The cardinal areas are noticeably wider medially than at the extremities, and are very finely striate longitudinally. The surface of both valves is smooth except for the faint lamellose growth lines. These are prominent on the anterior third of the shell but are visible over most of the surface. They indicate a much more transverse juvenile stage, the mature shape being attained by dis-

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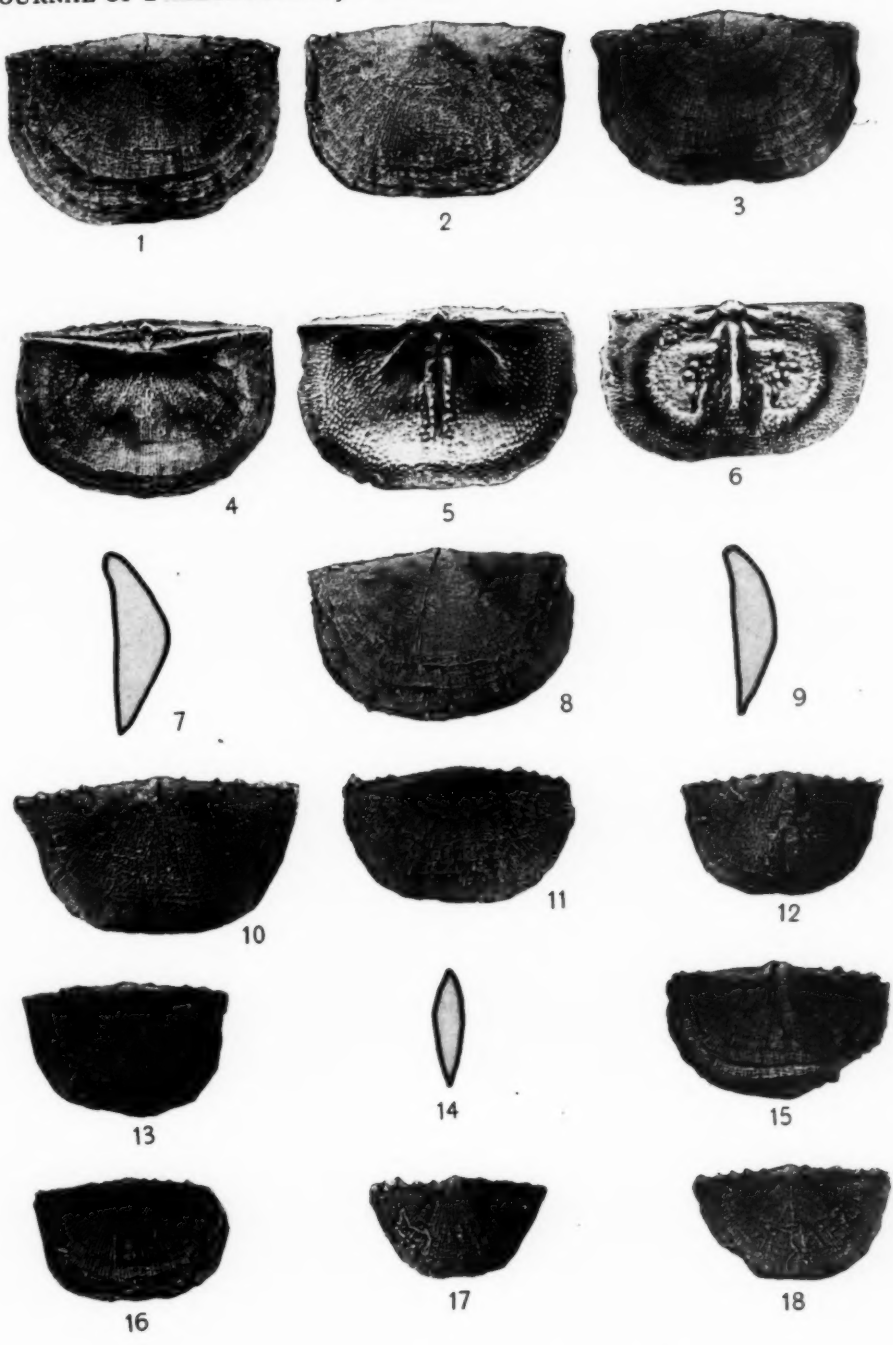
EXPLANATION OF PLATE 36

FIGS. *1–7—Chonetes dominus* King, n. sp. *1–3*, Ventral view of three individuals from the Marble Falls formation in a cut on the Llano road 2.7 miles south of San Saba, San Saba County, Texas, K-262, K-276, K-268; *4*, dorsal view of another individual from the same locality, K-273; *5*, *6*, ventral and dorsal interior of free valves from the same locality, K-274, K-260; *7*, a profile. (p. 259)

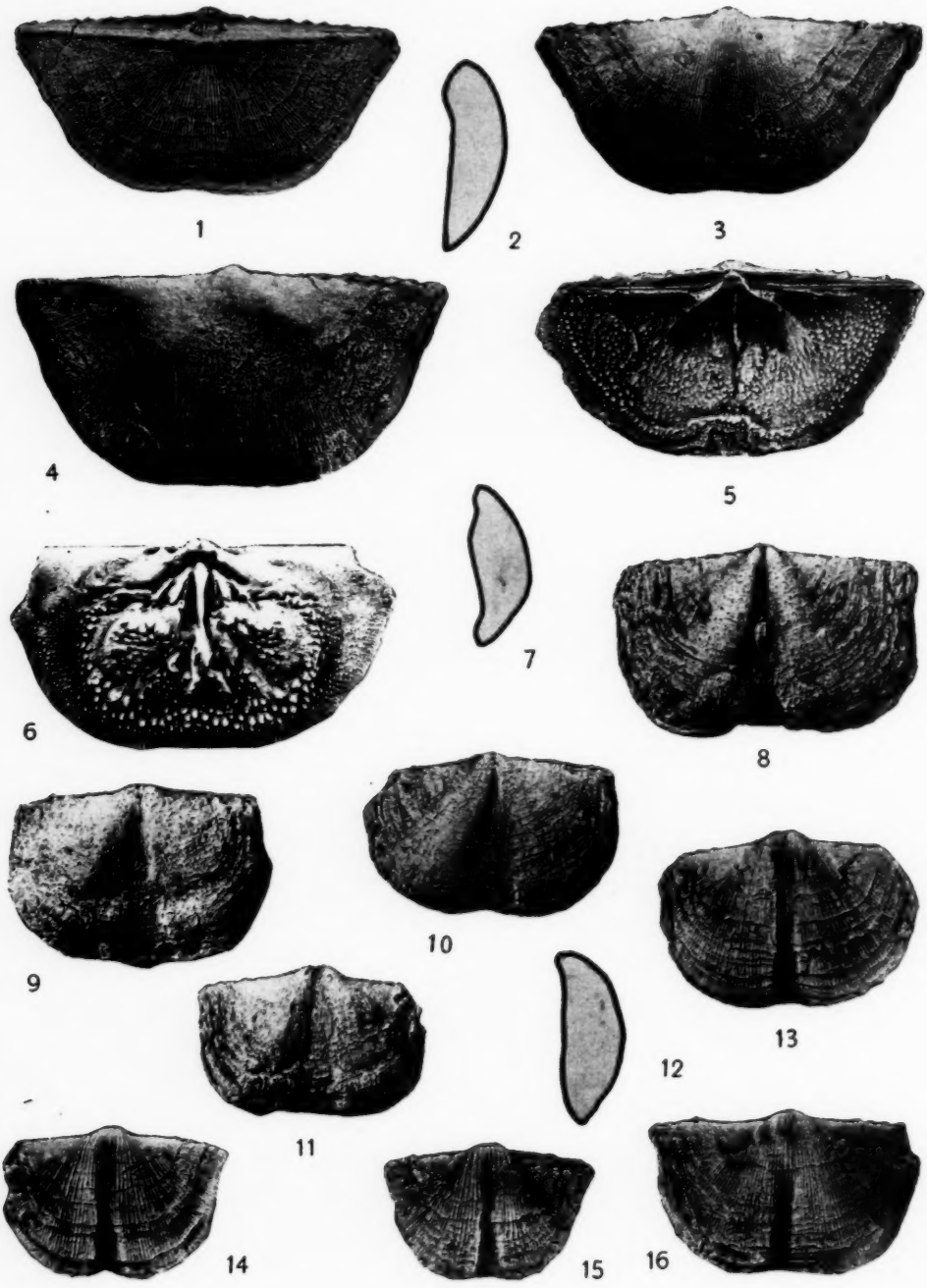
8–13—Chonetes fragilis King, n. sp. A profile and ventral views of five individuals from the East Mountain shale member of the Mineral Wells formation west of the cemetery at Mineral Wells, Palo Pinto County, Texas, K-709. (p. 260)

14–18—Chonetes granulifer Owen var. *emaciatus* King, n. var. A profile and ventral views of four individuals from the South Bend shale member of the Graham formation on the old Jacksboro road 2.2 miles east of Bryson, Jack County, Texas, K-172.

All figures ×2. (p. 261)



King, Paleozoic Chonetidae from Texas



King, Paleozoic Chonetidae from Texas

proportionately rapid growth at the anterior margin. Weathered shells appear lirate, which is a common occurrence among smooth Chonetidae.

The delthyrium is partially filled by a small deltidium. Below this in mature shells there is a recession out of which projects the posterior portion of the median septum. On young specimens this portion is narrow but on fully mature individuals it is a square blade with a horizontal dorsal and a vertical anterior edge, which descends nearly to the valve floor before meeting the dorsal edge of the long anterior portion of the septum. This portion extends to the anterior edge of the visceral area as a low rounded ridge of almost uniform height. The diductor muscle scars are long and narrow and are restricted to the area representing the lateral humps. Posterolaterally they are limited by extremely high steps, especially remarkable in view of the thinness of the shell. Anteromedially they are limited by the ridges representing the grooves that separate the fold in the sinus from the lateral humps. The adductor muscle scars have the form of low, broad triangles with their bases separated by the median septum and with their apices at mid-length and directed laterally. They are bounded by shallow grooves. In a few large specimens there are low short lateral ridges. They are about the same size as the septum and are parallel to it, but separated from it by a space about equal to their width. They gradually die out well back of the mid-length of the valve. Most individuals do not show this feature. The surface except the muscle scars is covered with radial rows of very low, rounded papillae, more noticeable but less regularly arranged on the outer flange.

In the dorsal valve the crura are low and broad and are directed laterally parallel to the hinge line. Their inner ends curve posteriorly to the cardinal process and partially enclose a small pit. The front edge of the pit is a low ridge rounding into the crura. The median septum runs forward, low, broad, and flat-topped, to near the mid-length, where it begins to rise sharply to form a thin triangle, descending rapidly thereafter to disappear near the edge of the shell. On each side of the septum is a high rounded asymmetric lateral ridge. The inner faces of the ridges are steep slopes with an anteriorly directed, low-lying spine forming the crest. The outer slopes are longer and convex. The ridges broaden out and terminate rather abruptly just back of the mid-length. The muscle scars are sharply outlined by the crura, the lateral ridges, and the median septum, but are so faintly impressed in the thin shell that their anterior limits are indiscernible. Just within its lateral and posterior margins the shell is thickened into a low ridge, which joins the crura on their posterior sides near their lateral extremities, but the

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EXPLANATION OF PLATE 37

FIGS. *1–6—Chonetes puebloensis* King, n. sp. *1–4*, A profile and dorsal and ventral views of one individual and ventral view of another from the Pueblo formation on the Cisco-Moran road 1 mile north of Pueblo, Callahan County, Texas, K-353; *5*, *6*, ventral and dorsal interior of two free valves from the Harpersville formation in a road cut northeast of Randolph College, Cisco, Eastland County, Texas, P-5773. (p. 262)

7–11—Chonetina? primitiva King, n. sp. A profile and ventral views of four individuals from the Salesville shale member of the Mineral Wells formation on a hillside above the road 3 miles west of the city limits of Mineral Wells and east of Brazos River, Palo Pinto County, Texas, K-3, K-4. (p. 264)

12–16—Chonetina robusta King, n. sp. A profile and ventral views of four individuals from the Millsap Lake formation in a creek bed 3½ miles east and 1 mile south of Rochelle, McCulloch County, Texas, K-137. (p. 265)

All figures ×2.

anterior part of the visceral area is not delimited. On the anterior portion of the shell on each side of the fold there is a greatly thickened subtriangular area ornamented with strong radial ridges, some of which are broken up into individual strong papillae. Around the margins of the shell are very fine papillae, closely spaced in radial rows.

Dimensions (in millimeters) and proportions of five specimens:

Width	Length	Thickness	L/W	T/W
14.9	9.9	2.8	.66	.19
14.4	10.0	2.8	.69	.19
14.4	9.6	2.8	.67	.19
13.4	9.0	2.3	.67	.17
8.8	5.7	1.8	.65	.20

The large size, strong lobation, and low convexity will distinguish *M. rochellensis* from any other now known, except possibly *M. inflexus* (Girty). That form, however, has a very narrow, very depressed median lobe, so that the anterior margin is deeply sinuate. If, as Girty states, it has radial lirae, that would serve further to distinguish the two forms. However, the Chonetidae are very deceptive in this respect, and some Texas specimens otherwise indistinguishable from *M. inflexus* are smooth.

This species is very abundant at an isolated locality in Colorado River valley where it occurs in association with *Chonetina robusta* King, n. sp. in strata tentatively correlated with the Millsap Lake formation.

Syntypes.—Bureau of Economic Geology nos. K-142, K-1721, and K-1722, from a creek bed 3½ miles east and 1 mile south of Rochelle, McCulloch County, Texas, 271 individuals, 71 free ventral and 52 free dorsal valves.

Genus PAECKELMANNIA Licharew, 1936

PAECKELMANNIA DERELICTA

King, n. sp.

Plate 38, figures 16–22

Specimens of this species have an arcuate margin with the curvature of the anterolateral margins only slightly exceeding that of the anterior and lateral margins. The lateral margins commonly converge slightly but on some individuals they are parallel and rarely are divergent. The cardinal extremities are nearly right angles. The posterior margins meet at the beak at an angle of about 168°. There is no trace of a fold or sinus.

The umbo is high and prominent, extending back of the cardinal border if not crushed. The posterolateral areas are markedly concave. The longitudinal curvature decreases regularly toward the front of the shell. The transverse profile is sharply rounded over the median third of the shell, but the lateral slopes are straight and would, if extended, meet at an angle of about 65°. Most specimens are flattened by crushing, but the height of an undistorted specimen is nearly a fourth the width. The dorsal valve is almost uniformly concave.

The entire surface of the shell except a small portion of the umbo and the corresponding part of the dorsal valve is covered with thin lamellose growth lines. There are numerous rather regularly arranged pits left by the removal of the fine surface spines from both valves. The surface is smooth, but the outer shell layer is transparent, and the radial structure of the underlying layer gives the shell the appearance of being radially lirate. About five of these pseudolirae occupy a space of 1 mm. near the margin. There are five or six large erect spines on each side of the beak. They diverge from the posterior margin at an angle of about 65°. The cardinal areas are longitudinally striate. The ventral is a little wider than the dorsal and both are wider medially than at the extremities.

Within the ventral valve the median septum extends from the middle of the deltidium downward and forward to the floor of the valve at a point just back of the anterior end of the adductor muscle scars. It continues forward for about a millimeter as a low, thickened ridge, and dies out well back of the mid-length of the shell. The lateral ridges diverge very slightly and continue beyond the end of

the septum, gradually declining to about the mid-length of the shell where they disappear. The adductor muscle scars are elongate oval and outlined by a broad groove except where separated by the median septum. The diductor muscle scars are roughly triangular and partially enclose the adductor muscle scars. Their anterior margins form an almost straight line, which is slightly convex forward, and a distinct but low ridge limits their posterolateral margins. The papillae are low and rounded and rise from slight depressions. They are comparatively scarce and are prominent only near the margins. The largest ones occur just within the visceral area near the hinge line.

In the dorsal valve the crura are prominent ridges parallel to the hinge line. A thickened ridge running roughly parallel to the margins limits the visceral disc and rounds into the anterior side of the crura near their outer extremities at an angle of about 30°. The posterior muscle scars are deep and smooth, and are limited posterolaterally by the ridge delimiting the visceral area. Medially they are bounded by the lateral ridges, which diverge at an angle of about 30°. Each ridge has an anteriorly directed spine at its anterior end. The anterior muscle scars are deep and elongate and are separated by a very low median septum. Over the posterior third of the shell it is much less prominent than the lateral ridges, but it rises and descends abruptly, forming a sharp triangle just back of the center of the shell. There are two large blunt anteriorly directed spines on its anterior slope. The visceral area is smooth near the ridge limiting the anterolateral portions, but the remainder is covered with strong papillae, which might almost equally well be termed spines. They are low-lying and variously but predominantly anteriorly directed. Outside the visceral disc the papillae are very numerous but small and fine.

Dimensions (in millimeters) and proportions of two somewhat crushed specimens:

Width	Length	Thickness	L/W	T/W
18.9	13.6	4.5		
12.0	8.8	3.5	.73	.29

The writer knows of no other species of this genus from the Pennsylvanian of North America. The absence of a sinus will distinguish it from specimens of *Lissochonetes* and *Mesolobus* except possibly *M. decipiens* (Girty), which is a subquadrate shell without the prominent umbo of this species.

This species occurs in the so-called Smithwick black shales overlying the Marble Falls limestone in the vicinity of Bend, San Saba County, Texas.

Syntypes.—Bureau of Economic Geology no. K-218, from dry gully 1.3 miles from Bend on the Cherokee road, San Saba County, Texas, 18 individuals, one free dorsal and one free ventral valve.

Superfamily STROPHOMENACEA Schuchert, 1896

Family PRODUCTIDAE Gray, 1840

Sub-family PRODUCTINAE Waagen, 1884

Genus JURESANIA Fredericks, 1928

JURESANIA RECTANGULARIA King, n. sp.

Plate 39, figures 9–12

Juresania rectangularia is a small, short, very transverse species with a noticeable sinus, which is most strongly developed at the mid-length of the shell. The anterior margin is straight or nearly so. The lateral margins are straight and subparallel or very broadly rounded and slightly divergent anteriorly. The greatest width of the shell is well in front of the mid-length except on shells with parallel lateral margins.

The umbo is low and broad and the beak scarcely extends beyond the hinge line. The longitudinal curvature is sharp, but decreases somewhat anteriorly. The lateral slopes are steep, but the small arched ears are not sharply set off from the rest of the shell. The umbonal slopes are very steep and form an angle of about 90°, but the angle decreases somewhat anteriorly. In transverse profile the flat-

tened or sinuate median portion of the shell rounds sharply into the flattened lateral slopes.

The dorsal valve is flat with a sharply upturned margin. There is a small shallow depression just in front of the beak, and the ears are slightly concave.

There is a small cicatrix of attachment on the ventral valve. The hinge is linear. The dorsal valve is ornamented with rounded concentric wrinkles, which become lamellose on the upturned margins. These are swelled into small pustules from which project fine spines. On some specimens these swellings have the appearance of low, rounded, radial costae, especially along the median line. The ventral valve is ornamented with several concentric rows of small oblique spines. Except on the umbo there are also scattered erect spines, much larger than the oblique ones. They are about 0.8 mm. in diameter and usually arise just behind the rows of small spines. The growth lines are lamellose around the margins of the shell.

Dimensions (in millimeters) of three specimens, disregarding the marginal flange:

Width	Length	Thickness
22.3	16.6	9.6
20.2	16.7	8.4
21.8	17.1	9.6

Juresania rectangularia has thus far been found only in the Brad formation, where it is associated with *J. ovalis* Dunbar and Condra. It is not likely to be confused with that shell, which attains a much larger size, is much more elongate, has much finer spines, and lacks the marginal flange. *J. nebraskensis* (Owen) resembles *J. rectangularia* much more closely, but may be distinguished by its much larger size, its lower convexity, somewhat more elongate outline, and coarser spines.

Syntypes.—Bureau of Economic Geology no. K-86, 6 specimens from the Brad formation in the gullies northwest of McAdam's Peak, 1½ miles east of Pickwick, Palo Pinto County, Texas.

Genus DICTYOCLOSTUS Muir-Wood, 1930

DICTYOCLOSTUS NEWELLI King, n. sp.

Plate 39, figures 1–4

Dictyoclostus newelli is a rather large, very transverse species. The anterior margin is broadly sinuate but the trail is broken off all the specimens so far seen. The lateral margins are subparallel and nearly straight. The umbo is broad and low and extends but little beyond the hinge line. The umbonal angle is about 105° to 115°. The ears are large and arched, and are sharply set off from the rest of the shell. The greatest width is at the hinge line. A broad shallow sinus appears behind the mid-length and continues to the anterior margin, but is commonly strongest at the mid-length of the shell.

The visceral area of the dorsal valve is very broadly concave except for a low broad median fold and a shallow depression in front of the beak. The margins are sharply upturned, but, as previously stated, the trail is broken off all the available specimens. The ears are concavely arched.

The dorsal valve is ornamented except on the ears and probably the trail with very fine radial costae and concentric rugae of about equal strength. The costae increase by splitting so that there are about 5 in a space of 5 mm. near the margins, but they are finer and more closely spaced near the beak. The ventral valve is similarly reticulate on the umbo but only the costae continue over the anterior portion. They number about 4 in a space of 5 mm. on this part of the shell. There are numerous small scattered spines on the ventral valve and a single row of larger spines along its posterior border.

Dimensions (in millimeters) of three specimens, the trail being broken off:

Width	Length	Thickness
48.7	36.2	19.4
44.5	34.6	18.2
45.2	32.9	18.3

D. newelli is larger than *D. portlockianus* (Norwood and Pratten) and has finer and more even costae. It is also much more transverse than that species and its umbo is less inflated. *D. crassicostatus* Dunbar and Condra is also a smaller less transverse form than *D. newelli* and has very much coarser costae. *D. americanus* Dunbar and Condra attains a much larger size and is a more elongate form without a distinct sinus. *D. welleri* King, n. sp. is a much more convex form with an inflated umbo and extended beak, and it also is much less transverse. *D. newelli* is not likely to be confused with any form so far known except possibly *D. americanus* Dunbar and Condra.

D. newelli occurs in the Caddo Creek and Graham formations but is not abundant in either. Some fragments from the Thrifty formation apparently belong to this species but cannot be positively identified.

Syntypes.—Bureau of Economic Geology no. K-1101, 2 specimens, and K-1621, 1 specimen, all from the Graham formation in a bluff south of the road two miles east of Fife, McCulloch County, Texas.

DICTYOCLOSTUS WELLERI King, n. sp.

Plate 39, figures 5–8

Productus semireticulatus var. cf. *hermosanus* Girty. PLUMMER and MOORE, *1921*, Univ. Texas Bull. 2132, pl. 25, figs. 3, 4.

Dictyoclostus welleri is a rather large extremely convex species with an elongate outline. The anterior margin is broadly rounded and rounds more sharply into the lateral margins, which are straight except for the extended ears. The ears are large and very strongly arched, but are not sharply set off from the rest of the shell. The umbo is strongly inflated and extends well back of the hinge line. The umbonal angle is about 97°. Most specimens show a distinct sinus, but on many it is scarcely more than a flattening of the median portion of the shell. The lateral slopes are very steep to sub-parallel.

The dorsal valve is deeply and evenly concave, with a sharply defined depression just in front of the beak. The intersection of the arched ears with the concave surface forms two broad low ridges extending from the beak to the lateral margins.

On the dorsal valve the costae and rugae are of about equal prominence. The rugae are broadly rounded; the costae are narrow and rather widely separated. On the ventral valve the costae are finer and more closely spaced than the rugae. They are sharp as on the dorsal valve, and the rugae are broadly rounded. Numerous rather fine spines ornament the ventral valve, and the posterior slopes of the ears are covered with much larger, more closely spaced spines. The body spines are commonly situated on costae that are stronger than the rest. All costae increase in size toward the anterior margin, where they number about 5 in a space of 5 mm. but they are much finer and more closely spaced on the umbo.

On several shells the umbo and even some parts of the anterior slope have been attacked by some boring organism.

Dimensions (in millimeters) of three specimens:

Width	Length	Thickness
58	41.6	23.2
45	34.7	22.4
49	35.2	23.2

The greater size and elongate outline will distinguish *D. welleri* from *D. portlockianus* (Norwood and Pratten) and *D. crassicostatus* Dunbar and Condra. The umbo of *D. welleri* is narrower and more inflated than in those species, also. *D. americanus* Dunbar and Condra is a larger, broader form, with less convexity, and its umbo is broader. *D. newelli* King, n. sp. is much more transverse and somewhat flattened on the umbo instead of fully rounded. *S. wolfcampensis* R. E. King resembles *D. welleri* more closely than does any other form. However, it is

slightly less convex and has finer, more even costae and finer, more closely spaced rugae. With specimens of both species in hand *D. welleri* can be distinguished at a glance by its rough appearance, which is due to the very marked unevenness of the costae.

D. welleri is rather abundant in the lower part of the Putnam formation and it is present in the lower part of the overlying Admiral and the upper part of the underlying Moran formations.

Syntypes.—Bureau of Economic Geology nos. K-1008, 3 specimens; K-1009, 2 specimens; K-1010, 3 specimens; K-1011, 2 specimens; K-1016, 2 specimens; K-1017, 2 specimens, all from the lowest limestone of the Putnam formation, which is exposed in an outlier south of the road 2.3 miles west of Putnam, Callahan County, Texas.

Genus MARGINIFERA Waagen, 1884
MARGINIFERA SCINTILLATA
King, n. sp.

Plate 39, figures 13, 14

Marginifera scintillata is a small, very convex form. The anterior margin is broadly rounded to slightly sinuate, but is nearly straight. The lateral margins are nearly straight and sub-parallel; the anterolateral margins are sharply rounded. The ears are large, arched, and quadrate. The greatest width is at the hinge line. The tightly incurved beak projects but little beyond the hinge line. The sinus is faint and is strongest at mid-length. The lateral, anterior, and umbonal slopes are all very steep. The umbonal angle is about 95°. The umbo is somewhat flattened and the shell is geniculate.

The surface is ornamented with fine low rounded costae, of which there are about 9 or 10 in a space of 5 mm. near the anterior margin. They increase by splitting. There are also a few scattered spines.

Dimensions of the holotype: width, 13.2 mm.; length, 10.9 mm.; thickness, 10.9 mm.

M. scintillata resembles *M. missouriensis* Girty in some respects but it has finer costae and coarser spines than that species, it is more sharply geniculate, and its lateral slopes are more nearly parallel. *M. wabashensis* (Norwood and Pratten) is a more transverse shell with a deeper sinus and a shorter, broader beak, and is not apt to be confused with *M. scintillata* as it occurs much higher in the section. *M. haydenensis* Girty is much more sharply geniculate and is also more transverse, and its beak is broader and not extended beyond the hinge line.

Holotype and three paratypes.—Bureau of Economic Geology no. K-1117, from the Kickapoo Falls limestone member of the Millsap Lake formation at Kickapoo Falls of Kickapoo Creek in Hood County, Texas, about a mile south of the Parker County line.

Genus LINOPRODUCTUS Chao, 1927
LINOPRODUCTUS INORNATUS
King, n. sp.

Plate 39, figures 23–26

The outline of juvenile specimens of *Linoproductus inornatus* is transversely elliptical, but by disproportionately rapid growth at the anterior margin the outline grades through subcircular to elongate elliptical on old specimens. The anterior margin becomes more abruptly rounded and the anterolateral margins become more broadly rounded with advancing growth. The hinge line is very short and the ears are little more than an outward flare of the umbonal slopes. The umbo is broad, and the beak does not extend far beyond the hinge line. There is no trace of a sinus, but specimens from the youngest strata in which the species occurs are somewhat flattened medially. The longitudinal curvature gradually decreases anteriorly. The transverse profile is broadly rounded medially and rounds sharply into the straight lateral slopes, which are only moderately steep. The umbonal angle is about 110°.

The dorsal valve is broadly concave,

the curvature gradually decreasing anteriorly. The ears are slightly concave. On specimens which are flattened medially on the ventral valve there is a low, broad fold on the dorsal valve. A few widely spaced lamellose growth lines cover the anterior half of the valve.

There is a very small cicatrix on the beak of some specimens but apparently not on all. The hinge is linear. Both valves are covered with low, rounded lirae or costae, which increase by splitting and occasionally by intercalation. Near the margin of a specimen of average size they number quite uniformly 8 in a space of 5 mm. but they are somewhat finer and more closely spaced on the umbo. There are a few spines scattered about the ventral valve, most of which are about 8 or 10 mm. apart. On some specimens there are about two or three spines on each ear arranged in a row along the posterior margin. The ears are strongly wrinkled, but the wrinkles do not encroach on the umbonal slopes.

Dimensions (in millimeters) of four specimens:

Width	Length	Thickness
40.5	42.2	20.9
29.1	26.9	14.0
28.4	26.5	13.5
17.6	14.8	6.5

L. inornatus appears in the East Mountain shale member of the Mineral Wells formation and is abundant in the Salesville and Keechi Creek shales of that formation. It continues upward to the top of the Graham formation but is not abundant in that very fossiliferous formation.

The very short hinge line, small ears, and low convexity will distinguish *L. inornatus* from any of the other similar linoproductids except possibly *L. meniscus* Dunbar and Condra, which is a much larger, more convex species with a narrower umbo. However, even *L. meniscus* Dunbar and Condra has a longer hinge line in proportion to its size and has larger ears ornamented with numerous spines.

Syntypes.—Bureau of Economic Geology no. K-1487, 4 specimens from the Jacksboro limestone member of the Caddo Creek formation in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas.

Genus CANCRINELLA Fredericks, 1928

CANCRINELLA ALTISSIMA

King, n. sp.

Plate 39, figures 27, 28

Cancrinella altissima is an extremely high, narrow, elongate form, broadly geniculate about 9 to 12 mm. from the beak. The best specimen, selected as the holotype, is 29 mm. in length, measured from the flattened posterior surface to the broken anterior margin. Following the curvature of the valve the length is 48.5 mm. One side of the specimen is damaged, but the maximum width was about 33 mm. The thickness was about 20 mm. There is an anterior prolongation of the ventral valve formed by constriction of the anterolateral margins, but this may be due to crushing, as there is some fracturing of the shell. The ears, though damaged, appear to have been extended, the greatest width being at the hinge line. The posterolateral or umbonal slopes are very steep. There is no trace of a sinus. Commonly the anterior trail is broken off, leaving only the umbonal portion as a subhemispherical body about 20 mm. in diameter and about 10 mm. in height.

The dorsal valve is evenly concave except for the ears, which are flat with a slight depression just in front of and parallel to the hinge line. The hinge is linear; there is no cardinal area.

The lirae are low and rounded and increase by splitting, especially at the spine bases. They become somewhat larger anteriorly. About 10 occupy a space of 3 mm. near the beak, but near the margin about 7 or 8 cover an equal space. The rugae are low, with the posterior slope more abrupt. The spines are erect and are arranged in diagonal rows, or quincunx.

A complete specimen would not be confused with *C. boonensis* (Swallow) but

the broken fragments commonly found are less easily distinguished. They are, however, much less convex ventrally and much less concave dorsally, have fewer and less conspicuous rugae, and have fewer spines on the umbonal portion. *C. boonensis* attains a maximum diameter of about 12 mm. and is obviously mature at that size, the thickness being nearly three fourths the length. *C. altissima*, however, is only about half as thick as long at a diameter of about 20 mm.

Holotype.—Bureau of Economic Geology no. P-7030, from the Graham formation on the west side of a small outlier one-half mile west of South Bend, Young County, Texas. Paratypes, P-4898 from the Graham formation 3 miles west of Bunger, Young County; P-4862 from the Graham formation 1 mile west of Graham, Young County; K-1091 from the Graham formation 2 miles east of Fife, McCulloch County, Texas; and K-1299 from the Graham formation south of Parks Mountain, Coleman County, Texas, five specimens in all.

Genus OVERTONIA Thomas, 1914
OVERTONIA PLUMMERI King, n. sp.

Plate 39, figures 19–22

Overtonia plummeri is small and subhemispherical. The lateral and anterior margins have a uniform curvature, which gives the shell a circular outline, with its greatest width at the mid-length. The umbo extends well back of the hinge line, but the beak is tightly incurved. The longitudinal curvature, therefore, gradually decreases anteriorly. The umbonal angle decreases from about 100° to about 80°. Because the hinge line is short and is greatly overarched by the umbo the ears are very small but are sharply set off. There is no trace of a sinus. The dorsal valve is concave except for the flattened ears, the curvature decreasing regularly anteriorly.

The hinge is linear. The ventral valve bears concentric rounded ridges that have about equal anterior and posterior slopes. The growth lines are more prominent between than upon ridges, because at the crest of each ridge there is a single row of large oblique spines. The buried base of each spine can be traced down the posterior slope of the ridge as a slight elevation. Near the anterior margin of the shell the spines are much more numerous but not much more widely spaced nor larger than near the beak. There are about 5 in a space of 5 mm. measured along the ridge. The ridges are about 2 mm. from crest to crest near the anterior margin. On the dorsal valve the spines are finer and project from lamellose growth lines. The spines on the ears are not differentiated from the rest on either valve. The lumen runs forward from the spine base within the shell substance, as Dunbar and Condra (1,*b*) have demonstrated to be true of other Productidae.

Dimensions (in millimeters) of three specimens:

Width	Length	Thickness
14.8	15.9	7.8
11.4	11.0	6.4
8.9	10.5	3.8

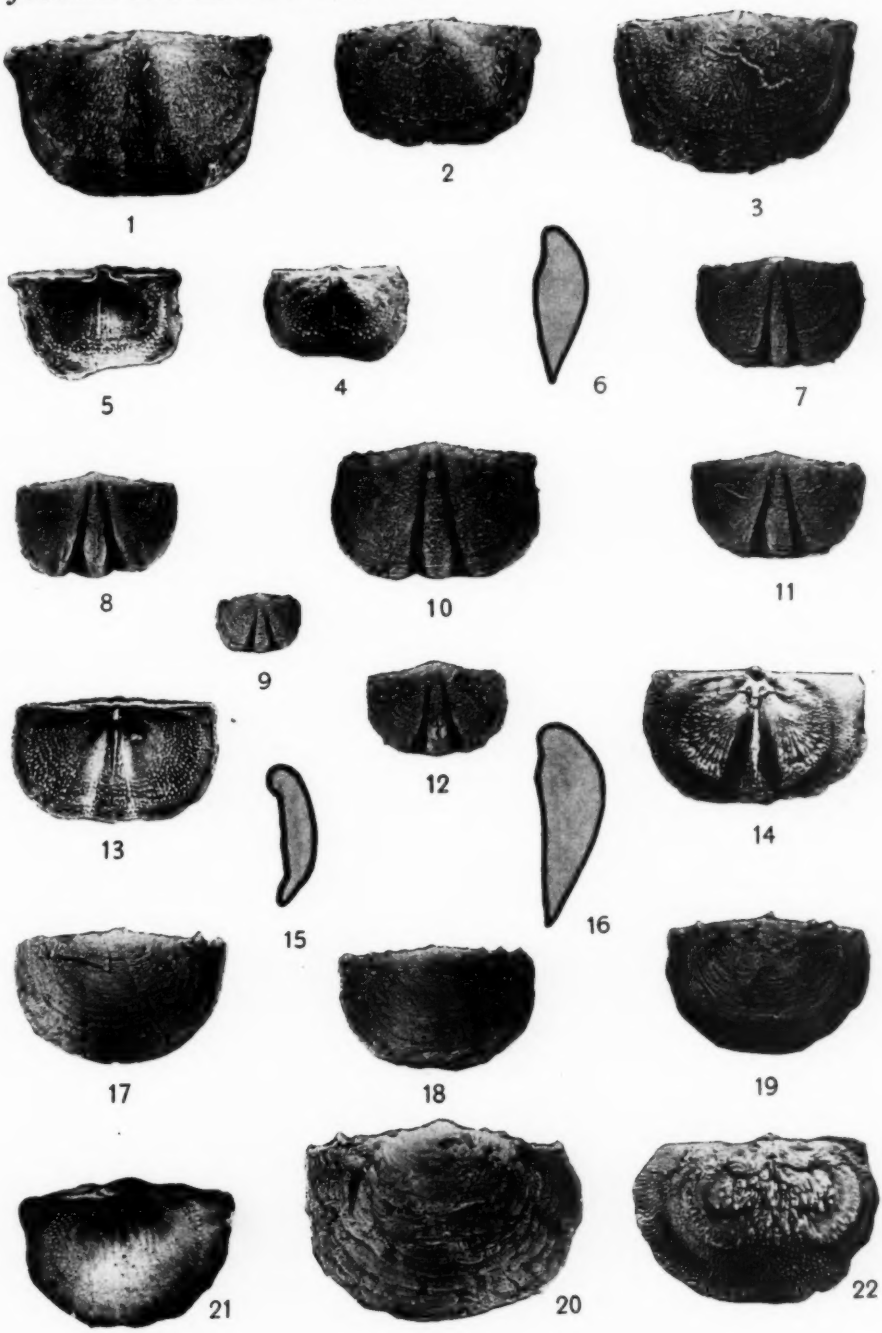
EXPLANATION OF PLATE 38

FIGS. *1–6—Lissochonetes primarius* King, n. sp. *1–3*, Ventral views of three individuals from a shale parting in the Jacksboro limestone in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, K-1489; *4, 5*, dorsal and ventral interior of two free valves from the same locality; *6*, a profile. (p. 266)

7–15—Mesolobus rochellensis King, n. sp. *7–12*, Ventral views of six individuals from the Millsap Lake formation in a creek bed 3¼ miles east and 1 mile south of Rochelle, McCulloch County, Texas, K-1721; *13, 14*, ventral and dorsal interior of free valves from the same locality; *15*, a profile. (p. 268)

16–22—Paeckelmannia derelicta King, n. sp. *16*, A profile; *17–20*, ventral views of four individuals from the so-called Smithwick shale in a dry gully on the Cherokee road 1.3 miles from Bend, San Saba County, Texas, K-218; *21, 22*, ventral and dorsal interior of free valves from the same locality. (p. 270)

All figures ×2, except fig. 20, ×1.



King, Paleozoic Chonetidae from Texas

King, Paleozoic Productidae from Texas

So far as is known to the writer no other species of *Overtonia* has yet been reported from North America with the exception of R. E. King's (4) citation of *Overtonia cristato-tuberculata* (Kozlowski)? from the Wolfcamp and Graham formations. His figures are poor, and even the specimen examined, the original of his figure 1, offers little to indicate the nature of the species except to show that it is not *O. cristato-tuberculata*. It is nearer to *O. plummeri* but it is impossible to say whether it is identical or not. *O. cristato-tuberculata* has only nine to eleven spines in each row, their size and the space between them increasing with the growth of the shell. The spines of *O. plummeri* are almost uniformly spaced and of equal size on all parts of the shell. Furthermore, the dorsal spines also are regularly arranged in concentric rows. *O. plummeri* differs from the genotype, *O. fimbriata* (Sowerby), in its much smaller size and its smaller, more closely spaced tubercle-bearing ridges.

The regular convexity of the ventral valve and the absence of any trace of a sinus or fold seem to be valid generic characteristics that will serve to distinguish the genus *Overtonia* from *Pustula* and other Productid genera.

O. plummeri has been found only in the Wayland shale and seems to be a rather rare form. A single immature individual from the Graford formation may belong to this species.

Holotype.—Bureau of Economic Geology no. P-4860, from the west bank of Salt Creek west of Graham, Young County, Texas. Paratypes, nos. 11980, 1 specimen; 12200, 2 specimens; and P-243, 1 specimen, all from the same locality; and P-719, 3 specimens, and K-320, 2 specimens, from 1 mile south of Gunsight, Stephens County, Texas.

EXPLANATION OF PLATE 39

FIGS. *1–4—Dictyoclostus newelli* King, n. sp., ×⅔. *1, 2*, Ventral and lateral views of specimens from Graham formation at bluff south of road, 2 miles east of Fife, McCulloch County, Texas, K-1101; *3, 4*, exterior and interior views of specimens from Graham formation one-half mile east-northeast of Weedon School, Brown County, Texas, P-6571, P-6796. (p. 272)

5–8—Dictyoclostus welleri King, n. sp., ×⅔. *5–7*, Lateral, ventral, and dorsal views of a specimen from an outlier of the lowest limestone of the Putnam formation south of road, 2.3 miles west of Putnam, Callahan County, Texas, K-1011; *8*, ventral view of another specimen from the same locality, K-1011. (p. 273)

9–12—Juresania rectangularia King, n. sp., ×1½. *9, 10*, Ventral and dorsal views of a specimen with slightly crushed umbo from the Brad formation northwest of McAdams Peak, Palo Pinto County, Texas, K-86; *11, 12*, ventral and lateral views of another specimen from the same locality, K-86. (p. 271)

13, 14—Marginifera scintillata King, n. sp., ×1½. Ventral and oblique views of the holotype from Kickapoo Falls limestone member of the Millsap Lake formation, Kickapoo Falls, Hood County, Texas, K-1117. (p. 274)

15–18—Heteralosia slocomi King, n. sp., ×1½. *15, 16*, Exterior of ventral and dorsal valves of genoholotype showing characteristic ornamentation, from Graham formation at Parks Mountain, 4 miles south of Whon, Coleman County, Texas, K-1311; *17, 18*, ventral and dorsal interior of same specimen. (p. 278)

19–22—Overtonia plummeri King, n. sp., ×1½. *19–21*, Ventral, lateral, and dorsal views of the holotype, a specimen from the Graham formation on the west bank of Salt Creek west of Graham, Young County, Texas, P-4860; *22*, dorsal view of another, slightly crushed, specimen from the same locality, P-243. (p. 276)

23–26—Linoproductus inornatus King, n. sp., ×1½. *23*, Ventral view of specimen from the Caddo Creek formation in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, P-4872; *24, 25*, lateral and anterior views of another specimen from the same locality, K-1487; *26*, dorsal view of another specimen from the same locality, P-6987. (p. 274)

27, 28—Cancrinella altissima King, n. sp., ×1. Lateral and ventral views of the holotype from a small outlier of the Graham formation one-half mile west of South Bend, Young County, Texas, P-7030. (p. 275)

Subfamily STROPHALOSIANAE Schuchert, 1913

Genus HETERALOSIA King, n. gen.

Strophalosia, pars.

The genus *Strophalosia* as established by Wm. King (5) in 1844 included Productidae with a cardinal area, a "deltidium," and a denticulate hinge. It included forms with a spinose ventral valve and spinose, lamellose, or smooth dorsal valve. The type species, *Orthis excavata* Geinitz, has a spinose dorsal valve. Although this is not made clear in the original description (6) it is definitely stated in a later (7) paper. It now seems desirable to separate from *Strophalosia* the species that have a smooth dorsal valve, and to these it is here proposed to apply the name *Heteralosia*, n. gen.

The species included in *Heteralosia* are Productidae and Strophalosinae that have a cardinal area on each valve, a cicatrix of attachment on the umbo, a "delthyrium" at least partially filled by a "deltidium," teeth in the ventral valve and sockets in the dorsal valve, and spinose ornamentation on the ventral valve but none on the dorsal valve.

The genus is distinguished from *Strophalosia* Wm. King by the absence of ornamentation on the dorsal valve. The point of attachment on the umbo will distinguish *Heteralosia* from *Aulosteges* Helmerson, which is not attached, and from such forms as *Leptalosia* Dunbar and Condra, which are attached by the entire surface of the ventral valve. The cardinal area will distinguish it from the spinose Productinae.

Heteralosia is represented in the late Pennsylvanian and Permian by such species as *Strophalosia gerardi* Wm. King, *Strophalosia tenuispina* Waagen, and the genotype, *Heteralosia slocomi* King, n. sp.

HETERALOSIA SLOCOMI King, n. sp.
Plate 39, figures 15–18

Strophalosia spondyliformis White and St. John. HALL and CLARKE, *1921*, Paleontology of New York, vol. 8, pt. 1, pl. 17A, figs. 25, 26.

Specimens of *Heteralosia slocomi* are subcircular in outline with small scarcely extended ears. The greatest width is in front of the mid-length and exceeds the width along the hinge line by at least half. The anterolateral margins are somewhat more abruptly rounded than the anterior or lateral margins.

The umbo is low and broad and is truncated by the cicatrix of attachment. However, the umbonal slopes are steep and the small ears are sharply set off. The thickness is about one-third the width and there is no trace of a sinus or fold. The ventral valve is therefore broadly and evenly rounded, and the dorsal valve rather deeply and evenly concave. The shell substance is very thin.

The ventral valve is covered with spines about 4 mm. in length near the margin of a mature individual, but these are commonly broken to mere knobs. There is a row of spines along the cardinal border. The dorsal valve is smooth, but faint growth lines are discernible on the anterior half.

The ventral cardinal area is broadly triangular but is only about one-tenth as high as wide. It is striate in both directions. The angle of the "delthyrium" is about 25° or less and it is about two-thirds filled by a depressed convex "deltidium." The dorsal cardinal area is narrow, almost linear, except medially, where it is raised into a low triangle.

Within the ventral valve the teeth project at the borders of the "delthyrium." Low broadly rounded ridges hardly deserving the name of dental lamellae descend from the base of the teeth and limit a broad shallow umbonal cavity, the median third of which is more deeply excavated to form a pit under the "deltidium." There is no median septum except the rounded slightly elevated line between the adductor muscle scars. These are slightly raised and together form a transverse, nearly elliptical area of slight eccentricity with the long axis pulled somewhat anterior to the center, so that each has the form of an imperfect sagging **D**. The diductor muscle scars lie outside and behind the adductors and do not enclose

them. Each is traversed longitudinally by two strong rounded ridges on the median portion, the outer one extending to the base of the dental "plate." The lateral portion of each scar is deeply depressed. The entire area of muscle attachment is roughly semicircular. The inside of the valve, except the muscle scars, is covered with very small, scattered blunt spines. The lateral margins are deeply excavated in front of the hinge line.

In the dorsal valve the dental sockets are deep and the cardinal process is long and narrow. The median septum forms a high triangle on the median third of the valve, but the posterior portion is rather low. The muscle scars form a slightly raised disc divided medially by the septum and the grooves adjacent to it. The brachial impressions are very faint. They apparently enclosed an elliptical area except that their anterior ends are separated by nearly a third the width of the valve. Near the posterior margin the lateral margins are depressed, to form with the corresponding depression of the ventral valve a sizable cavity for some undetermined soft part. Except on the muscle scars and brachial impressions the valve is ornamented with small spines similar to those of the ventral valve.

Heteralosia slocomi is not likely to be confused with any other North American species so far known. Although Hall and Clarke referred it to *Strophalosia spondyliformis* White and St. John, it does not closely resemble that species, which Dunbar and Condra (1,*c*) referred to their new genus *Leptalosia*. Dunbar and Condra and also Girty (8) realized that Hall and Clarke's identification was erroneous. Dr. A. W. Slocom of the Walker Museum, for whom this species is named, writes (9) that the specimen figured by Hall and Clarke was not from Missouri, as stated, but from Graham, Texas, and that it bears no resemblance to *Leptalosia spondyliformis* (White and St. John). *Strophalosia hystricula* Girty resembles *Heteralosia slocomi* but it is more convex —not evenly convex but sharply rounded medially, and the ears are indistinct. The dorsal valve of Girty's species is unknown, but it seems inadvisable to refer it to *Heteralosia* on the basis of its similarity to *H. slocomi*.

H. slocomi has thus far been found only in the Graham formation in north-central Texas.

Holotype.—Bureau of Economic Geology no. K-1311, from the Graham formation in the gullies at the south end of Parks Mountain, 4 miles south of Whon, Coleman County, Texas, separated valves of one individual. Paratypes, nos. P-723, from the Wayland shale member of the Graham formation 1 mile south of Gunsight, Stephens County, Texas, 1 specimen, and 11964, from the Graham formation 1 mile northwest of Graham, Young County, Texas, free ventral valve.

REFERENCES

1. DUNBAR, C. O., and CONDRA, G. E., Brachiopoda of the Pennsylvanian system in Nebraska: *Nebraska Geol. Survey*, ser. 2, vol. 5, pp. 133–175, 1932. *a*, Table facing p. 28. *b*, pp. 179–181. *c*, Pp. 262–263.
2. WELLER, J. M., and MCGEHEE, REX, Typical form and range of *Mesolobus mesolobus: Jour. Paleontology*, vol. 7, pp. 109–110, 1933.
3. GIRTY, G. H., *Washington Acad. Sci. Jour.*, vol. 24, p. 541, 1934.

3a. DUNBAR, C. O., Personal communication supported by Kansas specimens

4. KING, R. E., The geology of the Glass Mountains, Texas, pt. 2: *Texas Univ. Bull.* 3042, p. 82, pl. 20, figs. 1–3, 1931.
5. KING, WILLIAM, *Annals and Mag. Nat. History*, vol. 14, p. 313, 1844.
6. GEINITZ, H. B., Über einige petrefakte des Zechsteins und Muschel Kalks: *Jahrb. für Mineralogie*, Band 24, pp. 578–579, pl. 10, figs. 12–13a, 1842.
7. GEINITZ, H. B., *Verstein. der deutsch. Zechstein-gebirg.*, pp. 14–15, pl. 5, figs. 27–37; pl. 6, fig. 20, 1848.
8. GIRTY, G. H., The Guadalupian fauna: *U. S. Geol. Survey Prof. Paper* 58, p. 275, 1908.
9. SLOCUM, A. W., Personal communication dated Oct. 31, 1934, enclosing copy of label from Hall and Clarke's type.

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A FOSSIL DUCK FROM THE EOCENE OF UTAH

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ABSTRACT

A specimen from the upper Eocene (Uinta C) extends the paleontological record in North America of the family containing the ducks and geese from the Miocene. The species here described is somewhat similar to the living ruddy ducks *Erismatura* though separated in a distinct subfamily.

Comparatively few extinct species of ducks and geese have been discovered in North America. Most of the numerous fossil records for this group pertain to living species whose bones are found in Pleistocene or rarely in Pliocene deposits. The oldest known member of this group from our continent to date has been *Presbychen abavus* Wetmore, a goose from the Miocene deposits of California, though in the Old World the order has a much more complete paleontological record.

It is of interest therefore to report an extinct duck from the upper Eocene of Utah based on material placed in my hands for study by Dr. Glenn L. Jepsen, of the Department of Geology of Princeton University. A description of this specimen, which includes portions of the left wing, follows. Drawings illustrating it have been made by Sydney Prentice.

SYSTEMATIC DESCRIPTION

Subfamily EONESSINAE Wetmore, n. subfam.

Genus EONESSA Wetmore, n. gen.

Characters.—Those of the species described below.

Genotype.—*Eonessa anaticula* Wetmore, n. sp.

EONESSA ANATICULA Wetmore, n. sp.

Text figures 1–5

Characters.—Wing somewhat similar to that of modern *Erismatura jamaicensis* (Gmelin)(1) but with bones relatively longer and more slender; metacarpal with carpal trochlea decidedly longer, narrower, and more compressed in its distal extension below; pisiform process heavier; second metacarpal with a pronounced excavation on the dorsal surface at the distal end; humerus with ulnar trochlea smaller and more elongated.

Description.—Humerus (fig. 1) with head missing, considerably flattened by pressure; ectepicondylar prominence slight; radial condyle somewhat elongated, relatively narrow; ulnar condyle relatively small, somewhat elongated, rising abruptly from the shaft in front and projecting somewhat behind, separated from the radial condyle by a distinct sulcus; entepicondylar prominence slight; shaft considerably flattened by pressure so that the finer details of its structure are obscured; a relatively large brachial depression evident; shaft slender, expanded below to support the condyles; deltoid crest strong and well marked.

Ulna (fig. 2) considerably flattened by pressure, distal portion missing; olecranon strong and large; internal cotyla a round cup, above which the olecranon rises abruptly; external cotyla flattened and only slightly concave; depression below the external cotyla for the articulation of the radius well marked and deeply impressed; impression for the attachment of the brachialis anticus long and well marked; shaft relatively slender,

but details of its structure obscured by distortion.

Radius (fig. 3) with distal end missing; humeral cotyla elliptical, deeply cupped; bicipital tubercle large and pronounced; shaft fairly strong.

Carpometacarpus (fig. 5) with parts of metacarpal I and the central section of metacarpal III missing, but otherwise in

FIG. 1.—*Eonessa anaticula* Wetmore, n. sp. Distal part of humerus, ×1½.

good condition; metacarpal I relatively long, thickened anteriorly to support the articulation for the pollex; sides slightly concave (projecting process missing); a distinctly impressed anterior carpal fossa; carpal trochlea broad and smooth on proximal articular surface, narrowed abruptly below to one-half this width, and on this anterior portion distinctly and sharply grooved; external face distinctly concave with a well marked

FIG. 2.—*Eonessa anaticula* Wetmore, n. sp. Proximal part of ulna, ×1½.

papillus for the external ligamental attachment; internal face irregularly concave, with a strong broad-based pisiform process; metacarpal II with shaft straight and relatively slender; at the distal end, on the dorsal surface, an elongated angular depression; tendinal groove rather slightly impressed; metacarpal III slender, joined distally to metacarpal II by a broad, strong symphysis.

Base of pollex only preserved, this being triangular in outline, with the base expanded to form a strong articular facet, and the shaft anterior to this abruptly narrowed to a slender, triangular bar.

First phalanx of second digit (fig. 4) elongated and narrow; proximal end expanded to form a relatively large meta-

carpal facet with concave surface; narrowed abruptly beyond this to a thin, rather narrow plate with a thickened dorsal margin; expanded distally to form a digital facet.

FIG. 3.—*Eonessa anaticula* Wetmore, n. sp. Proximal part of radius, ×1½.

All bones strongly fossilized, dark neutral gray in color.

Measurements.—Humerus: Transverse breadth at distal end (approximate), 12.8 mm; approximate length from distal end to the distal margin of the deltoid crest, 67.0 mm.

FIG. 4.—*Eonessa anaticula* Wetmore, n. sp. First phalanx of second digit, ×1½.

Ulna: Transverse breadth of proximal end (approximate), 9.3 mm.

Radius: Greatest diameter of proximal end, 4.7 mm; of shaft, 2.7 mm.

Carpometacarpus: Length, 45.0 mm; greatest transverse breadth of carpal trochleae, 4.2 mm; length of metacarpal I, 6.1 mm; transverse breadth of metacarpal II near center, 3.8 mm.

First phalanx of digit 2: Length, 20.3 mm.

FIG. 5.—*Eonessa anaticula* Wetmore, n. sp. Left metacarpal, including views of the proximal and distal ends, ×1½.

Occurrence.—Holotype, Princeton Department of Geology 14399, part of left wing. Uinta C horizon of the Eocene of Myton Pocket, Utah, collected by John Clark August 26, 1936, under the auspices of the Scott Fund of Princeton University. As the bones were found articulated, they come without question from one individual. As indicated in the description they are flattened by pressure but are in very fair condition as to

completeness. Dr. Jepsen informs me that the block of matrix from which they were removed also contained fragments of two turtles.

Remarks.—So far as may be told from the form of the wing, *Eonessa anaticula* was about as large as a lesser scaup duck (*Nyroca affinis*), but seemingly was a bird of less heavy form. The slender wing bones have the general appearance and proportions of *Erismatura*, the only genus of the Erimaturinae of which modern skeletons are available, but the differences pointed out in the diagnosis are such that they warrant proposal of a subfamily Eonessinae for the fossil. It is possible that the Eocene bird may prove to belong in a family distinct from the Anatidae should more of its characters in other parts of its skeleton become known.

From the Old World Lebedinsky has described in the family Anatidae a fossil from upper Eocene (upper Ludian) deposits near Romainville (Seine) east of Paris, France, as *Romainvillia stehlini* (2) from a metacarpal, tarsometatarsus, coracoid and furculum in the Museum of Natural History in Basle. While he suggests (3) that this bird might be placed in a separate group it remained for Lambrecht (4) to erect the subfamily Romainvillinae for this species and for *Gallornis straeleni* from the Cretaceous of Auxerre, France. Concerning the latter there is little to be said except that it is so very fragmentary that its systematic position must be considered uncertain at best.

As for *Romainvillia stehlini*, the metacarpal is distinct in form from that of *Eonessa*, the distal end, especially having a different outline, so much so that the two must be considered as belonging to different subfamilies. Lebedinsky compares his specimen rather closely with *Dendrocygna*. It may be noted that the Uinta C beds have been correlated with the Ludian of Europe (5), so that *Eonessa* and *Romainvillea* seem to have existed at approximately the same period.

REFERENCES

1. *Anas jamaicensis* GMELIN, *Syst. Nat.*, vol. 1, pt. 2, p. 519, 1789.
2. *Romainvillia stehlini* LEBEDINSKY, *Soc. paleont. suisse Mém.*, vol. 47, no. 2, p. 1, pl. 1, 1927.
3. *Soc. paleont. suisse Mém.*, vol. 47, no. 2, p. 7, 1927.
4. *Handb. Palaeornith.*, p. 351, 1933.
5. See OSBORN, H. F., *U. S. Geol. Survey Mon.* 55, p. 78, 1929.

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MONOCLONIUS FROM SOUTHEASTERN ALBERTA COMPARED WITH CENTROSAURUS

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ABSTRACT

The Ceratopsidae from Red Deer River that Lambe referred to *Centrosaurus* are quite distinct from *Monoclonius*, to which *M. sphenocerus* Cope, with laterally compressed sharp-edged nasal horn core and narrow premaxillae, appears to be properly referred. Cope's *M. recurvicornis*, with oval forwardly directed nasal horn core, is tentatively referred to *Centrosaurus* though it differs from any other known species of *Centrosaurus* in the shape and proportion of its horn cores.

Students of Cretaceous horned dinosaurs have not been in full accord as to the relationship of Cope's genus *Monoclonius* (3, 5) from the Judith River formation of Montana and Lambe's genus *Centrosaurus* (6, 7, 8) from the Pale beds of Alberta. Brown regarded *Centrosaurus* as a synonym of *Monoclonius* (1). He described three new species from the Pale beds along Red Deer River, Alberta, which he referred to *Monoclonius* (2). Lull, in his recent "Revision of the Ceratopsia" (9), gave Lambe's genus subgeneric rank and drew special attention to the great differences in the parietal crests of the two types.

Many fine skulls of *Centrosaurus* have been collected from the locality in which Lambe secured his type, and all have the posterior edge of the crest deeply indented, greatly thickened, and with two hooklike processes pointing inwardly from near the posterolateral extremity. From the anterior edge of the thickened crossbar one or two hornlike processes extend forward over the parietal fenestrae. Whether these hornlike processes were for the attachment of muscles, as suggested by Brown, or for defensive or other purposes, they show a very different development from the crest of *Monoclonius*. In the parietal crest of *Monoclonius crassus*, which has been regarded as the genotype (5, 9), the posterior "bar" is broad, thin, only slightly indented posteriorly, as in *Triceratops*, and the periphery has a series of thin-edged scallops.

While collecting vertebrate fossils from the uppermost strata of the Belly River series in the southeastern corner of Alberta last summer, my ambition of twenty years was realized in the discovery of two skulls which can be identified as *Monoclonius*. The smaller skull lacks all in front of the posterior edge of the nasal horn but, if complete, would have been nearly four feet long. In the second skull, which is nearly complete, much of the crest was washed out but most of this has been pieced together. This skull is about five feet long. It was collected from a place east of Manyberries, Alberta.

The larger skull (Geol. Survey of Canada no. 8790) is the basis of our present comparisons. The coalesced parietals so closely resemble those of Cope's type of *Monoclonius crassus* as to leave no doubt of their generic identity. The apex of the median bar carries undulations, and the posterior portion is broad and moderately thin and shows no evidence of any of the hornlike processes so diagnostic of *Centrosaurus*.

We are now able, for the first time, to characterize the genus *Monoclonius* and to show that *Centrosaurus* should be given full generic standing. When the preparation of the specimens is completed and the specific determination made, a more detailed description with

figures will be published. It is thought advisable, at this time, to draw attention to the generic distinction between *Monoclonius* and *Centrosaurus*.

Genus MONOCLONIUS Cope, 1876

Skull with facial portion long; premaxillae extending well in advance of nasal horn, lower edge not strongly convex, not perforated by interpremaxillary fontanelle; nasal horn core outgrowth of nasal bones, with great anteroposterior diameter at base, laterally compressed with sharp anterior and posterior edges; no brow horns; orbits near midlength of skull; frontal folding moderately well advanced; postorbitals well developed, giving a broad squarish skull behind the orbits; squamosals very short and well forward, with proximal part standing almost erect; coalesced parietals well arched anteriorly but flattening out posteriorly, posterior part broad and moderately thin; fenestrae wholly within the parietals; periphery scalloped but without epoccipitals.

An outstanding difference between *Centrosaurus* and *Monoclonius* is seen in the nasal horn. In our new specimen this horn core is totally unlike the long, ovoid horn core, with a sulcus at its base, found in *Centrosaurus*. It resembles that of *Chasmosaurus* (8, *a*) or even more that of *Brachyceratops* (4, *a*). The anteroposterior diameter of the base of the nasal horn is 165 mm and the greatest lateral diameter, toward the posterior edge, is 73 mm. There is no sign of a constriction or sulcus at the base as in *Centrosaurus*, but the surface continues down the side of the face. From the base to the apex, the horn decreases rapidly in both directions and ends in a sharp, compressed point 188 mm high, measured from the nasals, behind the horn. The anterior edge of the horn extends upward and slightly backward in a graceful curve which continues from base to tip. The horn core is divided throughout its entire length by the longitudinal suture between the nasals.

This longitudinal division is not regarded as of specific importance and only shows that the animal was immature. We have a skull of *Centrosaurus* in which the large nasal horn core shows a division throughout much of its length, though it is not well shown on the external surface. We now know the divided nasal horn cores in *Brachyceratops*, *Eoceratops*, *Monoclonius*, and *Centrosaurus*, and there is little question but that a horn was borne on the outgrowth of the nasals in *Anchiceratops* and *Arrhinoceratops*. It is probable that juveniles of all the Belly River and Edmonton forms had divided nasal horn cores.

The premaxilla in front of the nasal horn is much longer than in *Centrosaurus* but not so high (1, 2, 8) and the lower border is only slightly convex as in *Chasmosaurus* and *Triceratops*. The length between the nasal horn and the orbit is about as in *Centrosaurus* but the long horn base and the elongated nose makes the part in front of the orbit only slightly less than that behind.

There is no evidence of brow horns and the part of the postorbital that usually carries the horn core is perfectly smooth, even lacking vascular impressions. In some centrosaur skulls there is no brow horn core, but as far as I have observed there is at least a rugose bump.

The anterior part of the coalesced parietals is not unlike that of *Centrosaurus*, except that there are no epoccipitals, but the posterior part is broad and relatively thin. There is a slight notching of the posterior edge at the mid-line and the scallops are farther apart there than on the other parts of the periphery. There seem to be seven of these scallops, but due to a slight gap in the left side and the premortem injury of the right side, this is uncertain. There are seven scallops in the smaller skull mentioned above. The scallops run to a thin edge and could not have borne separate ossifications. Most of the crest is smooth but there are a few vascular impressions, which are more pronounced on the under side of the parietals. The exact size of the fenestrae cannot be given, as the extremely thin edge of the left side

is not complete and the right side was injured during the life of the animal. The right side suggests that that fenestra was completely closed with very thin bone, but crushing and poor preservation of this region precludes a positive statement. In the smaller skull the fenestrae are much as in *Centrosaurus* but smaller.

CONCLUSIONS

It is evident from the above discussion, that the Red Deer River forms that Lambe referred to *Centrosaurus* are quite distinct from *Monoclonius*. The laterally compressed sharp-edged nasal horn core and the narrow premaxillae of Cope's type of *M. sphenocerus* (5, *a*) would appear to be properly referred to *Monoclonius*. The type of Cope's *M. recurvicornis* displays a totally different development in the nasal horn core, which is oval in cross-section and directed forward. The presence of well-developed brow horns is also different. This species, therefore, must be removed from *Monoclonius* and might best be referred to the genus *Centrosaurus*, though the shape and proportion of the horn cores are quite different from those of any known specimens of *Centrosaurus*. A specimen representing this species, collected on Lost River last summer, consists of the left orbital rim with brow horn core, jugal, and squamosal. In this specimen the orbit, jugal, and squamosal are similar to those of *Centrosaurus*.

REFERENCES

1. BROWN, BARNUM, A complete skull of *Monoclonius* from the Belly River Cretaceous of Alberta: *Am. Mus. Nat. History Bull.*, vol. 33, art. 34, pp. 549–558, 1914.
2. ———, A complete skeleton of the horned dinosaur *Monoclonius* and description of a second skeleton showing skin impression: *Am. Mus. Nat. History Bull.*, vol. 37, art. 10, pp. 281–306, 1917.
3. COPE, E. D., Descriptions of some vertebrate remains from the Fort Union beds of Montana: *Acad. Nat. Sci. Philadelphia Proc.*, vol. 28, pp. 255–256, 1876.
4. GILMORE, C. W., *Brachyceratops*, a ceratopsian dinosaur from the Two Medicine formation of Montana: *U. S. Geol. Survey Prof. Paper* 103, pp. 1–38, 1917. *a*, fig. 2.
5. HATCHER, J. B., MARSH, O. C., and LULL, R. S., The Ceratopsia: *U. S. Geol. Survey Mon.* 49, pp. 70–96, 1907. *a*, p. 87, fig. 9.
6. LAMBE, L. M., New genera and species from the Belly River series (mid-Cretaceous): *Canada Geol. Survey Contr. Canadian Palaeontology*, vol. 3, pt. 2, pp. 57–63, 1902.
7. ———, Two species of horned dinosaurs from the Cretaceous of Alberta: *Ottawa Naturalist*, vol. 18, pp. 81–84, 1904.
8. ———, On *Eoceratops canadensis*, gen. nov., with remarks on other genera of Cretaceous horned dinosaurs: *Canada Geol. Survey, Museum, Bull.* 12, 1915. *a*, pl. 8.
9. LULL, R. S., A revision of the Ceratopsia or horned dinosaurs: *Peabody Mus. Nat. History Mem.*, vol. 3, pt. 3, 175 pp., 1933, *a*, p. 84.
10. STERNBERG, C. M., Homologies of certain bones of the ceratopsian skull: *Royal Soc. Canada Trans.*, 3d ser., vol. 21, sec. 4, pp. 135–143, 1927.

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CAMBRIAN FAUNAL SUCCESSION IN NEVADA AND CALIFORNIA

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ABSTRACT

All five zones of the Lower Cambrian are represented by the fauna of Nevada and California Only two of the Middle Cambrian zones are recognized, and only four of the Upper Cambrian. The species in each zone are listed.

During the preparation of a Cambrian correlation chart for the Committee on Stratigraphy of the National Research Council, the writer has accumulated a mass of new information concerning the succession of Cambrian faunas in the Great Basin. This paper presents a fuller explanation of some of the new correlations than could be presented in the form of footnotes on the chart itself.

There has been a tendency, especially pronounced in the last few years, to regard each Cambrian fossil as a member of a "fauna" or, exceptionally, of a number of consecutive "faunas" (1). Thus we speak of the *Cedaria* fauna, the *Crepicephalus* fauna, and the *Aphelaspis* fauna. By "fauna" in these cases is understood an aggregate of animals, conveniently denominated by citing a characteristic genus or species. Because in some instances there are known to be considerable hiatuses between faunas adjacent in the tables and charts, it is easy to come to regard each fauna as separated from its neighbor by a diastrophic "break," an unconformity. This is often a fallacious and pernicious conclusion, to which the field geologist is not easily induced to subscribe. He is acutely aware of the distinction between a paleontologic hiatus and an unconformity. The writer has no quarrel with the users of faunas (he uses them in this paper); he is conscious of the artificiality of such conveniences, and anxious to avoid misunderstanding. In the following discussion his reasoning is based entirely on faunal evidence, and in no wise on diastrophic evidence. It is the purpose of the paper to set forth the Cambrian faunas now known in California and Nevada, with some indication of their distribution within those states. Their occurrence in the better known sections of the Cambrian elsewhere will be shown in the correlation chart.

HISTORY OF EXPLORATION

The first news of Primordial fossils from Nevada was a short note reporting the presence of *Archaeocyathus* and other Lower Cambrian fossils near Silver Peak (2). Though the first to be discovered, the Lower Cambrian of Silver Peak is even today poorly known. Like the Cambrian of many other regions, that in the Nevada area has been elucidated in large part by Walcott. His early work on the faunas resulted in the description of many of the peculiar forms found near the structurally complex Eureka mining district (3). Hall and Whitfield also described some of these species (4). Because of the structural complications the stratigraphic import of these forms remained obscure. Even the large Eureka Atlas of Hague (5) does not make clear the stratigraphic relations of the localities.

A few years later Walcott worked in the more southerly Highland Range, where the Cambrian is excellently exposed (6). Fossils from this section and nearby Pioche were described in Bulletin 30. His published faunal lists do not give a clear picture of the faunal associations as now known. Pack (7) and Burling (8) have discussed this situation. It is only recently that the full significance

Distribution of Cambrian faunas in California and Nevada

Fauna	Marble Mountains	Providence Mountains	Sheep Mountain	Frenchman Mt., Virgin Mt., Key West Mine	N W. Spring Mts.	Desert Range	Groome district	Nopah-Resting Springs Ranges	Waucoba Springs	Palmetto Range (Barrel Spring)	Tybo district	Eureka district	Snake Range	Highland Range
Eurekia						*					*	*		*
Iddingsia						*					*	*		*
Elvinia						*		*					*	*
Tricrepicephalus					*									*
Ehmania		*			*			*				?	*	
Zacanthoides	*	*	*	*	*		*	*	?	?				*
Proliostracus														*
Nisusia		*										*		*
Syspacephalus		*	*											*
Olenellus	*	*	*	*	*		*	*	*	*		*		*
Nevadia										*				

of the Highland Range section has been realized. Attention having been focused upon the area by Professional Paper 171 (9), the writer has studied the faunas with the results shown in the distribution table.

For many years after the appearance of Bulletin 30 Walcott published few results of his further work in Nevada or California. In this interval Turner contributed to the knowledge of the Cambrian *A sketch of the historical geology of Esmeralda County, Nevada* (10). About the turn of the century the search for the earliest trilobite led Walcott to the Waucoba Springs section in the Inyo Range of California. Together with a section near Silver Peak, Nevada (the Barrel Spring section, measured by Gen. Weeks), this California area furnished him with material for several papers on the Lower Cambrian (11). Kirk later added to the knowledge of the Cambrian stratigraphy in the Inyo Range, in effect orienting Walcott's Waucoba Springs section in relation to the adjacent rocks above and below (12).

In the course of the structural studies in the Las Vegas area, Longwell has found many new Cambrian localities, the content of which is partly shown in the distribution table. The Virgin Mountain section yielded some fossils to him (13), and additional faunas have been found by Hazzard and the writer. The Upper Cambrian formations in the Desert Range have been described by Longwell in manuscript. Professor Longwell kindly supplied information about localities which enabled the writer to obtain samples of the faunas of that area. In the northwestern Spring Mountains, Nolan found a Lower Cambrian section similar to that of Longwell in the Sheep Range, cut off at the base by a thrust (14). Hazzard has found the same units in the Nopah Range, California. He and the writer have collected from this section faunas as shown in the distribution table. The Nopah section is notable for its fine exposure and lack of structural complications.

Lower Cambrian rocks in the Marble Mountains were first reported by Darton (15). Resser (16) later described several collections made by students at the University of California (Howe, Cavins, Clark, Hazzard), which included also a few Middle Cambrian forms. The writer further described this Middle Cambrian fauna, the most southerly in California (17). Hazzard and Mason

have described the Middle Cambrian formations of the Marble and Providence Mountains (18), and assembled as yet unpublished data on the Lower Cambrian units. The Marble-Providence Mountains section is similar to those of the Ivanpah quadrangle, California-Nevada, which Hewett has mapped (19). Part of this mapping has been published in a paper on the *Geology and ore deposits of the Goodsprings quadrangle, Nevada* (20).

The isolated Tybo district, in western Nevada, has yielded Upper Cambrian fossils of importance in paleogeography. Ferguson's map of the area reveals so much diastrophic complexity that a significant sequence seems unobtainable (21).

SUCCESSION OF CAMBRIAN FAUNAS

The place of each recognized faunal zone of Nevada and California in the standard Cambrian sequence is shown in the accompanying list.

Succession of Cambrian faunal zones

Standard sequence	Nevada-California representatives
Upper Cambrian	
Plethopeltis	
Saukiella	*Eurekia*
Eurekia	
Upper *Dikelocephalus*	
Scaevogyra	
Lower *Dikelocephalus*	
Briscoia	
Prosaukia	*Iddingsia*
Ptychaspis	
Conaspid	
Irvingella major	
Elvinia	*Elvinia*
Unnamed	
Aphelaspis	
Crepicephalus	*Tricrepicephalus*
Cedaria	
Unnamed	
Middle Cambrian	
"Kochaspis" upis	
Olenoides-Orria-Marjumia	
Elrathiella-Triplagnostus	*Ehmania*
Ehmania-Bolaspis-Glyphaspis	*Zacanthoides*
Glossopleura-Kootenia	
Zacanthoides-Anoria	
Lower Cambrian	
Proliostracus	*Proliostracus*
Nisusia	*Nisusia*
Syspacephalus	*Syspacephalus*
Olenellus	*Olenellus*
Nevadia	*Nevadia*

COMPOSITION OF THE FAUNAS

Lower Cambrian Faunas

Nevadia zone.—The only species known from the *Nevadia* zone are *N. weeksi* Walcott and *"Holmia" rowei* Walcott (22). They occur in the lower portion of the Barrel Spring section (U. S. Nat. Mus. loc. lf), and are separated from the next higher *Olenellus* fauna by an extrusive "andesite mass, 750 feet thick." Restudy of this section, to determine the nature and extent of the faulting and the vertical distribution of the fossils, is much

needed. It is gratifying that the reconnaissance work of Turner is now to be checked and amplified by Dr. George Anderson. It is more to be hoped that the reconnaissance studies of Noble, in the Death Valley region, will reveal a complete undisturbed section containing *Nevadia* and *Olenellus* in sequence.

Olenellus zone.—The *Olenellus* fauna has been identified in the minds of some readers as the only fauna in the Lower Cambrian. This is natural, for it is the most widely distributed zone in the Great Basin and elsewhere. And Walcott's *Fauna of the Olenellus Zone* (23) tends to strengthen this belief, for therein are illustrated many Lower (and Middle) Cambrian forms which never occur with *Olenellus*. The writer, in using the zone, is acutely conscious that there may be undeveloped evidence for splitting it. He suspects that such division is most possible upon the basis of the non-Olenellid species, such forms as *Syspacephalus* and *Antagmus*. But, as at present restricted, the *Olenellus* fauna contains, among many, the following species:

Species in the Olenellus fauna

Micromitra (*Paterina*) *prospectensis* Walcott
Olenellus? argentus Walcott
O. bristolensis (Resser)
O? claytoni Walcott
O. fremonti Walcott
O. gilberti Meek
O. insolens Resser
Paedeumias clarki Resser
P. mohavensis Crickmay
P. nevadensis (Walcott)
Wanneria? gracile Walcott
Peachella iddingsi (Walcott)

Post-*Olenellus* Lower Cambrian Faunas

The distribution table illustrates the peculiar importance of the Highland Range section for an understanding of the faunal sequence of the Lower Cambrian. To the writer's knowledge no other locality in the Great Basin furnishes as complete a succession of these forms. The Mt. Whyte formation of British Columbia contains similar fossils (24), but the available collections are difficult to use because of the lack of stratigraphic information concerning them. In northwest Greenland Poulsen found parts of a comparable sequence (25). Resser has studied this part of the section in the southern Appalachians, and his nomenclatorial revisions (26) have been of assistance in clarifying the paleontologic sequence, even though his stratigraphic data are not yet published. It may be that others will not agree that the faunas here termed "post-*Olenellus* Lower Cambrian" are really of that age; yet it must be admitted that they deserve a recognition in the standard faunal sequence that they have not heretofore received.

The lowest post-*Olenellus* zone is characterized by a few species very close to, if not identical with, forms accompanying *Olenellus*, just below. *Syspacephalus* is the only genus so far published represented in this zone. Forms resembling *Agraulos* and *Micmacca* (in part belonging to manuscript genera of Resser) are in the collections. Just above is the *Nisusia* zone, best developed in the Highland Range, where it contains *Kochiella*, *Kochaspis liliana* (Walcott), *Onchocephalus walcotti* Resser, *Poliella*, *Plagiura*, *Micromitra* (*Iphidella*) *pannula* (White); elsewhere in the Great Basin this assemblage is accompanied by *Nisusia* and *Proliostracus*. The highest zone so far known in the Lower Cambrian is found only in the Highland Range. Its fauna is small in number of species, and is composed of minute trilobites belonging to the genera *Proliostracus*, *Kootenia*, *Albertella*, and "*Strenuella*." The *Albertella* is smaller than any yet described, with a *Bonnia*-like cranidium; but its pygidium is relied upon as a safe generic criterion. Inasmuch as the overlying *Zacanthoides* zone is correlated with little doubt with the *Albertella* zone of the Canadian Cordillera, an *Albertella* in the Lower Cambrian is to be regarded as a primitive representative of the line of descent, an assumption corroborated by biologic considerations.

Middle Cambrian Faunas

The Middle Cambrian faunas of the Great Basin are not well understood because of poor preservation, lack of attention, and mixture of certain faunules. Further work will surely provide closer correlations than here attempted.

Zacanthoides zone.—The lower fauna recognized in the Middle Cambrian includes elements of three faunas representing the lower half of the epoch in northwestern Montana; however, the fauna of the Wolsey shale, equivalent to the present zone, indicates the local validity of Deiss' divisions in northwestern Montana. The fauna of this interval consists in part of the following species:

Species in the Zacanthoides zone

Chancelloria eros Walcott
Micromitra (*Iphidella*) *pannula* (White)
Acrothele subsidua (White)
Obolus (*Westonia*) *ella* (Hall and Whitfield)
Wimanella highlandensis (Walcott)
Eocrinus longidactylus (Walcott)
Alokistocare piochensis (Walcott)
A. strangulatus (Mason)
Anoria lodensis (Clark)
Asaphiscus spatha (Mason)
Bathyuriscus maximus Mason
"Bolaspis" trifossatus (Mason)
Clavaspidella howelli (Walcott)
Glossopleura packi Resser
G. mohavensis Resser
Glyphaspis nevadensis Resser
Kootenia masoni Resser
Zacanthoides typicalis (Walcott)

The relative positions of these forms, if that can be determined within Nevada and California, will probably emerge as the result of careful collecting in the group of sections: Frenchman Mountain, Virgin Mountains (Key West mine and Whitney Ridge), and Sheep Mountain. It is to be hoped that Mr. Russell Wheeler, working under Dr. McKee for the Carnegie Institution, will find fossils of these zones in the Lake Mead region.

Ehmania zone.—After a very considerable stratigraphic interval the next known fauna appears: the *Ehmania* zone. Though known over a very wide area by reconnaissance collecting, no locality from which well preserved material is obtainable is yet known. Tentative generic references have been published (27), and others are here added, yielding the following list:

Species in the Ehmania zone

Obolus sp.
Lingulella sp.
"Agnostus" sp.
Alokistocare n. sp.
Ehmania n. sp.
Ehmaniella n. sp.
Elrathia sp

Ehmania oweni (Walcott) may belong to this zone; the presence of this fauna at Eureka is not certain however. It is reported by Dr. Resser that representatives of the Marjum fauna (*Olenoides-Orria-Marjumia*) also occur at Eureka; lack of evidence forbids consideration here of what would be the sole occurrence of a very late Middle Cambrian fauna in Nevada.

Upper Cambrian Faunas

The classic surveys of the Eureka district discovered in limestone an abundance of trilobites of an age theretofore represented so far as known by sandstone. The doubt as to the age of the Hall and Whitfield and the Walcott species has been dispelled by careful work in the central United States. The beautifully preserved fossils of the West have been neglected, save for generic revision and a single illustrated paper (28). But recently areal studies by Longwell, Ferguson, and Westgate, and reconnaissance by Hazzard and the writer, have revealed several sections wherein the succession can be studied to good advantage. The stratigraphic paleontologist is indebted especially to Professor Longwell for the discovery of the very important Desert Range Upper Cambrian section.

Tricrepicephalus zone.—Though *Cedaria* is well known from the House Range, no specimen has been found in Nevada. The oldest Upper Cambrian fauna is quite close to that of the *Crepicephalus* zone of Texas and Missouri. So far as preliminary determinations go, the fauna contains:

Species in the Tricrepicephalus zone

Armonia sp.
"Blountia" globosa Miller
Bonneterrina sp.
Coosella n. sp.
Crepicephalus dis Walcott
Deiracephalus sp.
Kingstonia sp.
Marywillia sp.
Tricrepicephalus sp
Ucebia sp.

It includes, moreover, new forms referable to unpublished genera of Lochman from the Hickory sandstone and lower Cap Mountain formation of Texas (identified by Dr. Lochman, to whom I am indebted).

Elvinia zone.—This zone is the most widely distributed Upper Cambrian zone in the Great Basin. From its place of discovery, at White Pine, it has been traced south and west for a long distance, and it is the only Upper Cambrian zone at present known in California. Examination of a faunule from the Inyo Range (U. S. Nat. Mus. loc. 65c), referred to the Upper Cambrian by Walcott (29), reveals Middle or possibly Lower Cambrian forms; field examination of the section leads Hazzard and the writer to the conclusion that the presence of Upper Cambrian rocks in the Inyo Mountains remains unproved. Almost everywhere the *Elvinia* zone is represented by highly fossiliferous limestone nodules and layers in green shales containing only *Lingulella* sp. The *Elvinia* zone has yielded, among many, the following:

Species in the Elvinia zone

Lingulella arguta (Walcott)
Acrotreta pyxidicula (White)
Linnarssonella minuta (Hall and Whitfield)
Pseudagnostus n. sp.
Homagnostus n. sp.
Dunderbergia granulosa (Hall and Whitfield)
D. n. sp. aff. *D. granulosa* (Hall and Whitfield)
D. maculosa (Hall and Whitfield)
Elvinia roemeri (Shumard)
E. n. sp.
Pterocephalia sanctisabae (Roemer)
P. occidens Walcott
"*Conocephalites*" sp. cf. *C. hamulus* Hall

This is one of the largest faunas known in the area, sufficiently large that fairly exact correlation may be attempted. It is hoped that additional localities may be examined and collections obtained from them before the monographic study necessary is published.

Iddingsia zone.—The fossils of the zone provisionally termed *Iddingsia* zone have been confused with faunules of the underlying and overlying zones, particularly at Eureka. The only locality yet found in which the *Elvinia*, *Iddingsia*, and *Eurekia* zones can be easily distinguished is in the Desert Range. From limestones fifty feet above the green shales of the *Elvinia* zone the following have been collected:

Species in the Iddingsia zone

Dunderbergia n. sp.
Iddingsia affinis (Walcott)
"*Irvingella*" n. sp. (n. gen.)
Pseudagnostus n. sp.

The small faunule from Tybo referred to this zone contains a species of the *Irvingella*-like genus. Until larger collections can be made and examined, it is deemed unwise to attempt to place the many species described from about this horizon by Walcott and by Hall and Whitfield in the synthetic faunal sequence here outlined.

Eurekia zone.—Though in the Eureka district the faunules of the *Eurekia* zone contain extraneous elements, one lot collected by Walcott from the low hills west of the Highland Range (U. S. Nat. Mus. loc. 88) is clearly from this zone. Further collection by the writer at that locality, together with material obtained in the Desert Range, gives the following list from this, the highest Cambrian yet recognized in Nevada:

Species in the Eurekia zone

Eoorthis sp. cf. *E. desmopleura*
Pelagiella sp.
Owenella antiquata (Whitfield)
Hyolithes attenuatus Walcott
H. curvatus Walcott
H? corrugatus Walcott
Bowmania americana (Walcott)
Corbinia sp.
Euptychaspis sp.

Eurekia angustifrons (Walcott)
E. dissimilis
E. granulosa (Walcott)
Homagnostus sp.
Saukiella subgracilis Ulrich and Resser var.

The most abundant species is the small Gastropoda, *Owenella antiquata*, but trilobites of the genera *Eurekia* and *Bowmania* are always associated.

RELATION TO THE ORDOVICIAN

Exploration has not yet progressed to the point at which the Cambrian-Ordovician faunal relations can be discussed profitably, save in a very general way. At Eureka and in the Highland Range the highest Cambrian is adjacent to a fault of such displacement as to hide the upward succession. Collecting in the Desert Range is still in a stage preliminary to intensive work and may remain in that stage because of the cost. Apparently conformable beds above the *Eurekia* zone in that area may contain the transitional faunas so much sought after. At no other localities do the faunas known approach the Ordovician boundary so closely.

REFERENCES

1. E.g., RESSER, C. E., Preliminary generalized Cambrian time scale: *Geol. Soc. Am. Bull.*, vol. 44, p. 735, 1933.
2. WHITNEY, J. D., *California Acad. Nat. Sci. Proc.*, vol. 3, pp. 269–270, 1866.
3. WALCOTT, C. D., Paleontology of the Eureka district: *U. S. Geol. Survey Mon.* 8, 1884.
4. HALL, JAMES, and WHITFIELD, R. P., Paleontology: *U. S. Geol. Expl. 40th Par.* (*King.*) vol. 4, p. 199, 1877.
5. HAGUE, ARNOLD, Geology of the Eureka district: *U. S. Geol. Survey Mon.* 20, atlas, 1892.
6. WALCOTT, C. D., Second contribution to the studies on the Cambrian faunas of North America: *U. S. Geol. Survey Bull.* 30, pp. 33–36, 1886; Correlation papers; Cambrian: *U. S. Geol. Survey Bull.* 81, pp. 317–319, 1891.
7. PACK, F. J., Geology of Pioche, Nev., and vicinity: *School Mines Quart.*, vol. 27, p. 290, 1906.
8. BURLING, L. D., Early Cambrian stratigraphy in the North American Cordillera with discussion of *Albertella* and related faunas: *Canada Geol. Survey Mus. Bull.* 2, p. 93, 1914.
9. WESTGATE, L. G., and KNOPF, ADOLPH, Geology and ore deposits of the Pioche district: *U. S. Geol. Survey Prof. Paper* 171, 1934.
10. TURNER, H. W., *Am. Geologist*, vol. 29, p. 261–272, 1902.
11. WALCOTT, C. D., Cambrian sections of the Cordilleran area: *Smithsonian Misc. Coll.*, vol. 53, p. 167, 1908; Cambrian Brachiopoda; descriptions of new genera and species: *Smithsonian Misc. Coll.*, vol. 53, p. 53, 1908; *Olenellus* and other genera of the Mesonacidae: *Smithsonian Misc. Coll.*, vol. 53, p. 231, 1910; Group terms for the Lower and Upper Cambrian series of formations: *Smithsonian Misc. Coll.*, vol. 57, p. 305, 1912; and others.
12. KIRK, EDWIN, in KNOPF, ADOLPH. A geologic reconnaissance of the Inyo Range . . . , *U. S. Geol. Survey Prof. Paper* 110, 1918.
13. LONGWELL, C. R., Geology of the Muddy Mountains, Nevada: *U. S. Geol. Survey Bull.* 798, p. 23, 1928.
14. NOLAN, T. B., Notes on the stratigraphy and structure of the northwest portion of Spring Mountain, Nevada: *Am. Jour. Sci.*, 5th ser., vol. 17, p. 461, 1929.
15. DARTON, N. H., Discovery of Cambrian rocks in southeastern California: *Jour. Geology*, vol. 15, p. 470, 1907.
16. RESSER, C. E., Cambrian fossils from the Mojave Desert: *Smithsonian Misc. Coll.* vol. 81, no. 2, 1928.
17. MASON, J. F., Fauna of the Cambrian Cadiz formation, Marble Mountains, California: *Southern California Acad. Sci. Bull.*, vol. 34, p. 97, 1935.
18. HAZZARD, J. C., and MASON, J. F., Middle Cambrian formations of the Providence and Marble Mountains, California: *Geol. Soc. Am. Bull.*, vol. 47, p. 229, 1936.
19. HEWETT, D. F., manuscript in preparation.
20. HEWETT, D. F., *U. S. Geol. Survey Prof. Paper* 162, 1931.
21. FERGUSON, H. G., Geology of the Tybo district, Nevada: *Nevada Univ. Bull.*, vol. 27, no. 2, 1933.
22. See remarks by C. D. WALCOTT, *Olenellus* and other genera of the Mesonacidae: *Smithsonian Misc. Coll.*, vol. 53, pp. 257, 292, 298, 1910.
23. WALCOTT, C. D., *U. S. Geol. Survey Tenth Ann. Rept.*, p. 515, 1891.
24. WALCOTT, C. D., Fauna of the Mount Whyte formation: *Smithsonian Misc. Coll.*, vol. 67, no. 3, 1917.

25. POULSEN, CHR., The Cambrian, Ozarkian and Canadian faunas of northwest Greenland: *Meddelelser om Grønland*, vol. 70, p. 233, 1927.
26. RESSER, C. E., Nomenclature of some Cambrian trilobites: *Smithsonian Misc. Coll.*, vol. 93, no. 5, 1935; Second contribution to nomenclature of Cambrian trilobites: *Smithsonian Misc. Coll.*, vol. 95, no. 4, 1936; Third contribution to nomenclature of Cambrian trilobites: *Smithsonian Misc. Coll.*, vol. 95, no. 22, 1937.
27. HAZZARD, J. C., and MASON, J. F., Middle Cambrian formations of the Providence and Marble Mountains, California: *Geol. Soc. Am. Bull.*, vol. 47, p. 239, 1936.
28. WALCOTT, C. D., Cambrian and Ozarkian trilobites: *Smithsonian Misc. Coll.*, vol. 75, no. 3, 1925.
29. WALCOTT, C. D., in KNOPF, ADOLPH, A geologic reconnaissance of the Inyo Range . . . , *U. S. Geol. Survey Prof. Paper* 110, p. 32, 1918.

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PALEONTOLOGICAL NOTES

CORRELATION OF MIDDLE CAMBRIAN FAUNAS OF NORTH AMERICA

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The Middle Cambrian *Paradoxides* faunas of northwestern Europe and northeastern North America have long been well known to paleontologists, and during the last 50 years much has been learned about the Middle Cambrian faunas of the southeastern United States and the Rocky Mountain and Great Basin regions. But, in spite of the fact that students of the Cambrian have in recent years been familiar with hundreds of species of Middle Cambrian trilobites, brachiopods, and other animals from these regions, it has heretofore not been possible to make satisfactory correlations between the *Paradoxides* faunas of southeastern Newfoundland, southeastern New Brunswick, northwestern Vermont, and eastern Massachusetts and the faunas occurring between the youngest Early Cambrian and the oldest Late Cambrian beds of other parts of North America. Recent discoveries, which have added much to our knowledge of the Middle Cambrian of Newfoundland and the western United States, have, however, at last enabled us to determine, at least approximately, the relative ages of the eastern and western faunas, and give us reason to hope that we shall before long be able to make our correlations still more accurate.

These new discoveries have been made by a number of workers who have been cooperating in an effort to increase our knowledge of Cambrian paleontology and stratigraphy. C. E. Resser, C. F. Deiss, Christina Lochman, Erling Dorf, J. C. Hazzard, Donald Duncan, and C. H. Kindle have all made important contributions to our fund of information on the Middle Cambrian of this continent in recent years, and other investigators have also contributed significant facts. In preparing this paper the authors have drawn freely from the pool of new knowledge, some of it still unpublished, to which these workers in the Cambrian field have all contributed and which has been, by common agreement, made available to each of them. The credit for the new facts and conclusions which are here presented therefore belongs to their colleagues as well as to the authors, themselves.

The most complete and richly fossiliferous section of Middle Cambrian beds that has been discovered in northeastern North America is the one at Manuels, southeastern Newfoundland, which was described by the senior author in 1925 (1). In that section there are found the following four successive and easily recognizable *Paradoxides* faunas, with Lower Cambrian faunas beneath them and Upper Cambrian faunas above them, both separated from the *Paradoxides* faunas by stratigraphic breaks:

Parodoxides davidis fauna
Paradoxides hicksi—P. abenacus fauna
Upper *Paradoxides bennetti* fauna, with abundant *Paradoxides eteminicus* and numerous other trilobites
Lower *Paradoxides bennetti* fauna, with *Paradoxides eteminicus* rare or absent, but with *Dawsonia dawsoni* and *Ehmania rogersi* present.

The *Paradoxides* faunas of New Brunswick and Massachusetts can be closely correlated with these Newfoundland ones. The *Centropleura vermontensis* fauna of Vermont, which is of very late Paradoxidian age, is known to be somewhat younger than the highest of these Newfoundland faunas.

The best sections of Middle Cambrian rocks known in western North America are in northwestern Montana, in Nixon Gulch

near Three Forks, southern Montana, in the House Range of west-central Utah, in the Highland Range of eastern Nevada, and in the Providence Mountains of eastern California. Descriptions of a number of these sections and their faunas will be published in the near future by Professor Deiss, the junior author, and others.

The faunal succession in these sections may be summarized as follows:

"Kochaspis" upis fauna
Neolenus-Orria-Marjumia fauna
Elrathiella-Triplangostus fauna
Ehmania-Bolaspis-Glyphaspis fauna
Glossopleura-Kootenia fauna
Zacanthoides-Anoria fauna

On the Port au Port Peninsula, western Newfoundland, and at Canada Bay, northeastern Newfoundland, the senior author has found *Ehmania* faunas. On the Port au Port Peninsula the fauna includes undescribed species of *Elrathiella* and *Glyphaspis*, but these genera have not been found in Canada Bay and the Port au Port fauna is probably younger than the Canada Bay one. Neither this Port au Port fauna nor the similar fauna found at Canada Bay is known to contain *Paradoxides*, but the trilobite long known in the earliest *Paradoxides* faunas of eastern Massachusetts and southeastern Newfoundland as *"Ptychoparia" rogersi* is now recognized as a species of *Ehmania*, and all these faunas are therefore believed to be of much the same general age.

Ehmania is a common genus in the middle part of the Middle Cambrian beds of the western United States. It is the characteristic genus of the *Ehmania* zone there, but ranges into the overlying *Elrathiella* zone.

Dawsonia, an Eodiscid, which occurs with *Ehmania* in the lower *Paradoxides* beds of Newfoundland and Massachusetts, was recently discovered by the junior author in an undescribed section near the Groom mining district, in southern Nevada. This western *Dawsonia* was found in beds containing *Strotocephalus* and *Kootenia*, believed to be in the *Zacanthoides-Anoria* zone.

No fauna had until recently been found in the Northeast that appeared to be of the same age as this oldest Medial Cambrian *Zacanthoides-Anoria* fauna of the West, but faunas perhaps of this age have been known for several years in Virginia and Tennessee (2).

Overlying the *Ehmania* beds in the House Range is the Wheeler formation, whose fauna includes undescribed species of *Triplagnostus* and *Bathyuriscus*, genera characteristic of the *Paradoxides hicksi* fauna of the Atlantic Basin. Above the Wheeler in the West are strata holding a fauna whose diagnostic genera are *Neolenus*, *Orria*, and *Marjumia*—the fauna of the Marjum formation of Utah. This latter fauna contains undescribed Agnostians very similar to species found in the *Paradoxides davidis* fauna of Newfoundland, which overlies the *Paradoxides hicksi* fauna, and the Marjum fauna is therefore believed to be of about the same age as the *Paradoxides davidis* fauna. The Stephen formation of British Columbia can be correlated with the Marjum, since it contains several of the genera characteristic of that formation. A fauna recently reported from near Noxon, Western Montana, in some ways resembles the Stephen fauna, but is probably somewhat later.

No fauna resembling the *Centropleura vermontensis* fauna of Vermont has yet been found in western North America. The latest well preserved Medial Cambrian fauna that has been discovered in the West is one that has as its most characteristic index species the trilobite *"Kochaspis" upis*. This fauna occurs stratigraphically above the *Ehmania-Elrathiella* faunas and is very different from them and from the *Neolenus-Orria-Marjumia* fauna elsewhere appearing in this position. Because it is thus different from those faunas, whereas the *Centropleura vermontensis* fauna resembles the *Paradoxides forchhammeri* fauna, which overlies and is closely related to the *Paradoxides davidis* fauna in northwestern Europe, it is believed that the *"Kochaspis" upis* fauna is somewhat younger than the *Centropleura vermontensis-Paradoxides forchhammeri* faunas, which are the youngest Medial Cambrian faunas known in the North Atlantic Basin (northeastern North America and northwestern Europe).

The writers therefore believe that the relative ages of the Middle Cambrian faunas of North America are approximately as indicated in the following table:

Correlation of Middle Cambrian faunas

	Zonal Fossils of North Atlantic Regions	Newfoundland	Cape Breton	New Brunswick	Massachusetts	Vermont	Gaspé	Pennsylvania to Alabama	Arizona	Nevada and California	Utah	Idaho and Washington	Montana and Wyoming	British Columbia and Alberta	Greenland (NW)	Zonal Fossils of Rest of North America
Menevian	Paradoxides forchhammeri and Centropleura		?			*							*			"Kochaspis" upis
Menevian	Paradoxides davidis	*		*					*	*	*	*		*		Neolenus-Orria-Marjumia
Menevian	Paradoxides hicksi	*		*						*	*		*	*	*	Elrathiella-Triplagnostus
Solvan	Upper P. bennetti with P. eteminicus	*		*	*											
							?			*	*		*		?	Ehmania-Bolaspis-Glyphaspis
Bonnetian	Lower P. bennetti with Dawsonia and Ehmania	*			*		?	*	*	*			*	*	*	Glossopleura-Kootenia
						* *	?	?	*	*	*	*	*	*	*	Zacanthoides-Anoria

The *Paradoxides hicksi*, *Paradoxides davidis*, and *Paradoxides forchhammeri* (and *Centropleura*) faunas of this table and their equivalents are considered to be of Menevian age: The upper *Paradoxides bennetti* fauna, with *Paradoxides eteminicus*, is of Solvan age. The lower *Paradoxides bennetti* fauna, with *Dawsonia* and *Ehmania*, together with the faunas which are correlated with them, are here assigned a new age and stage name, Bonnetian. This term is taken from the original name for the Highland Range of Nevada. It is possible that one or more of the faunas which underlie the *Zacanthoides-Anoria* fauna in western North America should also be assigned to the Bonnetian.

Since the *Paradoxides* faunas of Newfoundland, New Brunswick and Massachusetts and the *Centropleura* fauna of Vermont can be correlated with the *Paradoxides* and *Centropleura* faunas of Europe, Siberia, and Australia, while the Middle Cambrian faunas of western North America can be correlated with those of eastern Asia, our newly acquired ability to correlate the eastern and western North American Middle Cambrian faunas with each other will greatly assist in the correlation of the faunas of that epoch found in other parts of the world.

REFERENCES

1. HOWELL, B. F., The faunas of the Cambrian *Paradoxides* beds at Manuels, Newfoundland: *Bull. Am. Paleontology*, vol. 11, no. 43, 1925.
2. BUTTS, CHARLES, Geology of Alabama; the Paleozoic rocks: *Alabama Geol. Survey Special Report* no. 14, p. 73, pl. 8, 1926.

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SUPPOSED COLUMELLA IN TETRADIUM FIBRATUM SAFFORD

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In 1935, in my paper on Tetradidae (1), I described circular or irregular spots visible in cross-sections of some species of the Ordovician coral *Tetradium*. The persistency of these structures, their lenticular appearance in longitudinal sections, and their frequency, had led me to believe that they represent a sort of columella. Dr. R. S. Bassler, in a private communication, objected to this interpretation and suggested that the structure is due to replacement by clearer calcite. I am much indebted to Dr. Bassler for his friendly criticism of my work, for it caused me to reconsider the matter. I was particularly prompted to do this, as some more rather well preserved *Tetradium* material has come into my possession and offered an opportunity to extend the study of this very remarkable coral. I am much indebted to Miss M. Turner, a graduate student in the Dept. of Geology, Univ. of Toronto, who has prepared numerous nitrocellulose sections of *T. fibratum*.

This study demonstrated that the "spots" although present in many corallites are absent from others in the same stage of development and vary considerably in shape and in position within the corallites. There are all gradations from small central areas of clear calcite in mud-filled corallites to corallites completely replaced by clear crystalline calcite. In many instances each quadrant of the corallite has a spot of its own. In longitudinal sections the structure appears as a long wavy ribbon, in general occupying the central portion of a corallite.

In some corallites the central structure is made of crystalline calcite much like the calcite making up the septa and the walls; in others, the calcite is considerably finer grained, in a few instances indicating gradation to noncrystalline mud, which commonly fills the corallites. Examination of the condition of the ends of the septa seems to show that the septa may abut against the structure, penetrate it, or be deflected by it. The last condition, although suggestive of a true columella, is not conclusive because the septa are seldom very regular, and commonly the ends of the septa, even in corallites that have no "columella," point away from the center. It is quite probable that if the central structure is nothing but a recrystallized part of the calcareous mud that fills the corallites, the recrystallization started from the ends of the septa, and was in fact localized where the four edges come very close together in the central part of the corallites. In observed longitudinal sections, the inner rod is in contact with the edges of the septa over long distances.

The main difficulty in interpreting the structure lies in the comparatively poor preservation of the fossils, and in the lack of specimens in which either the original material making up the corallites is preserved, or at least is replaced in such a way that the original structure of the walls and septa is visible. At present a careful consideration of the problem makes me discard my previous interpretation and agree with Dr. Bassler that the central structure is not a columella but a replacement by clear crystalline calcite.

This does not seriously affect the systematic position of the group nor its subdivision into species. The last is based mostly on the shape of the corallum, the methods of building aggregates of corallites, the size of the corallites, and the number of the septa. The systematic position is probably best considered to be that of an independent branch of the Anthozoa with possibly distant relationship to such groups as the Chaetetidae, which also reproduce by fission (2).

REFERENCES

1. OKULITCH, V. J.: Tetradidae, a revision of the genus *Tetradium*: *Royal Soc. Canada Trans.*, sec. 4, vol. 29, pp. 49–74, 1935.
2. ———, On the genera *Heliolites*, *Tetradium*, and *Chaetetes*: *Am. Jour. Sci.*, 5th ser., vol. 32, pp. 361–379, Nov. 1936.

RESEMBLANCE OF THE CORAL MULTISOLENIA TO DESMIDOPORA

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Since the publication of my paper on the Middle Silurian genus *Multisolenia* (Jour. Paleontology, vol. 11, pp. 231–234, 1937) an earlier paper by Nicholson (On *Desmidopora alveolaris*, a new genus and species of Silurian corals: Geol. Mag., dec. 3, vol. 3, pp. 289–292, pl. 8, 1886) has come to my notice describing a similar coral from the Wenlock limestone of Dudley, England. Nicholson's figures of *Desmidopora alveolaris* resemble *Multisolenia tortuosa* Fritz both macroscopically and microscopically, but several features in his description make it difficult to reconcile the two species as congeneric. *Desmidopora* is described as having mural pores but no septa, whereas *Multisolenia* has septa but no pores.

Desmidopora alveolaris may actually have mural pores, but it is possible that Nicholson interpreted the cut ends of solenia as pores and failed to recognize the presence of tubes connecting the corallites. In *Multisolenia ortuosa* connecting tubes, or solenia, are a very conspicuous feature. With regard to the septa Nicholson states:

> No septa or septal spines are present. In examining the surface of well preserved specimens one might be easily led to suppose that irregular septa were here and there developed; but these apparent septa are really only inward projections of the walls of the corallites marking the boundaries of the separate tubes in the serially united rows.

Similar spiny projections are present in *Multisolenia tortuosa*, but there seems to be sufficient evidence to justify the belief that they are septa.

The object of this note is merely to call attention to the resemblance of the two corals. Whether or not they are congeneric cannot finally be decided until Nicholson's types have been reexamined. Though these two geographically widely separated corals may prove to belong to the same genus, they certainly represent different species.

REGARDING BOTHRIOLEPIS STENSIÖI SOHN

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In the Journal of Paleontology for January, 1938, a *Bothriolepis* shield is described as *Bothriolepis stensiöi* Sohn, n. sp. The specimen is a dorsum of a cephalic shield. The distinguishing characters of the species as given are the absence of the V-shaped groove of the sensory canal system and the greater convexity of the cephalic shield than in *Bothriolepis canadensis*. The latter character is unreliable, as examination of a number of cephalic shields demonstrates. In the Patten collection at Dartmouth College are shields of *Bothriolepis canadensis* both more and less convex than the photograph of *Bothriolepis stensiöi* would indicate.

The V-shaped groove Stensiö terms the "dorsal oblique pit-line" and regards as a part of the infraorbital system. He characterizes it as

> a shallow widely open groove which from a point situated about the middle of the lateral plate, close dorsomedially to the main division of the infraorbital groove, reaches as far posterodorsomedially as to a point on the median

nuchal plate [termed the median occipital in Sohn's account] close anterodorsomedially to the canal of the ductus endolymphaticus.

This groove is often indistinct, particularly the portion of it on the lateral plate. Usually it is more distinct on the median nuchal plate. In a number of specimens that I have examined it is difficult or even impossible to trace the groove on the lateral plate. Even on the median nuchal it is seldom, if ever, as deeply cut as is the main branch of the infraorbital. In the photograph, Sohn's figure 1, the median nuchal plate is either eroded or chipped, so that the ornamentation is obscured. This would render the groove or pitline very indistinct, if it did not eliminate it altogether.

The actual sensory canals seem to have been situated in soft tissue overlying the shield. Their impression on the bone would consequently vary. I have found in Osteostraci that frequently portions of the system that show on one side of the mid-line fail to show on the other side, although the preservation of the bone is just as good. Moreover we find asymmetry common in these canal impressions. On one specimen of *Bothriolepis canadensis* in the Patten collection, for example, the dorsal lateral line groove is normal on the right side, being directed diagonally backward on the trunk, whereas the same groove on the left runs back nearly parallel to and alongside of the median dorsal ridge.

I am thus inclined to discount single specimens as evidence for the lack of certain elements of the sensory canal system. Certainly it seems to be slight ground for the erection of a new species. Moreover Sohn states that the definition of the genus "should be expanded to include species without the V-shaped groove." Even were all trace of this groove lacking, I should want more data on the new species before admitting such an expansion of the definition of the genus or before accepting it as a valid new species. In the present instance the specimen appears to be a cephalic shield of *Bothriolepis canadensis* on which this line is obscure and in large part destroyed.

LESUEUR'S WALNUT HILLS FOSSIL SHELLS

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Through the kindness of William J. Fox, for many years the Librarian at the Academy of Natural Sciences of Philadelphia, I was directed to possibly the only informative account of the circumstances under which the drawings for Lesueur's *Walnut Hills Fossil Shells* were made. These were the first illustrations made from shells collected in the bluff at Vicksburg, Mississippi. The drawings are included in a series of five unpublished plates with 88 numbered figures, many of them with several views covered by the same number and with a very finely executed measured section of the bluff on which stood the ruins of Old Fort MacHenry. There is a copy of the plates in the Dall library in the U. S. National Museum and one in the Philadelphia Academy and doubtless a few more in the country, but they are rare. The plates are undated and unnamed though they are beautifully drawn and the fossils are readily recognizable. Dall has usually cited 1829 as the probable date, but has not discussed his reasons.

In 1904, the Société des Américanistes de Paris published in the fifth volume of their Journal "Les Voyages du Naturaliste Ch. Alex. Lesueur dans L'Amérique du Nord (1815–1837)," a book of 111 pages, 17 plates and 14 text figures, by the President of the Society, Dr. E. T. Hamy. The sixth chapter is entitled "De New-Harmony par l'Ohio et le Mississippi jusqu'à la Nouvelle-Orléans. Bone-bank, Walnut-Hills (1828)." William Maclure, the friend who was responsible for Lesueur's leaving France for America and for

his establishment as engraver in the Academy of Natural Science, in Philadelphia, returned to Philadelphia in 1824 after the disastrous failure of his attempt to establish near Alicante, Spain, an agricultural school in which physical labour and moral and intellectual training would be properly balanced. Robert Owen had recently taken over the New Harmony settlement, and Maclure, though he was dubious about some of the tenets of the faith upon which the community settlement was founded, saw in it a favorable center for his Agricultural School. So firmly did he believe in the promise of this humanitarian enterprise that he persuaded Troost, Thomas Say and Lesueur to abandon their established life in Philadelphia, to bring their equipment and to join him on the flatboat that was to transport them to New Harmony on the Wabash. They left Pittsburgh on November 27, 1825, 27 passengers and a crew of 10. On January 26, 1826, they reached Mount Vernon, where Maclure and a number of the other passengers left the boat to drive overland by wagon while Lesueur and the other naturalists followed the meanders of the Ohio to the mouth of the Wabash and up the Wabash to New Harmony. In New Harmony, Lesueur began his ambitious but never completed work on the Fish of North America. Say, Troost and Lesueur had little interest in the social aspects of the venture but were concerned with assembling material for a natural history museum for the instruction of the people in the community. With that end in view, Lesueur explored the country round about in an ever widening radius. New Harmony is in a region remarkable for the abundance of the Indian mounds, and Lesueur made those as well as the fauna the object of his investigation. In March 1828 he left New Harmony for New Orleans for a very personal reason, in order to see the French consul and to attempt to recover through him his pension which was so long overdue that he feared that he was listed among the dead. He secured passage with a family bound for New Orleans on a flatboat. Landings were fairly frequent, and collections of importance to archeology were made from the Indian mounds. Walnut Hill, the eighth of the "Bluffs of the Chickasaws," rose, in that day, from 250 to 300 feet high and was crowned by the ruins of old Fort MacHenry. At the base were the richly fossiliferous beds which had escaped Nuttall and other naturalists who had come that way. Lesueur made a large collection, later sent to the Musée de Paris, and measured the section which is reproduced as the frontispiece of his plates. After bringing his business affairs in New Orleans to a successful close, he took return passage on the steamboat Crusador. The sketches made on the return trip are, with many of his letters, in the collection of Havre. He did not reach New Harmony until the end of December, 1828, but the following year must have been occupied in part in making in New Harmony his plates for the Walnut Hills fossils. A letter from Memphis dated April 6, 1830, relates that he has sent to the Jardin du Roi the plates and explanatory text of the best preserved of the fossils which he collected at Vicksburg. Lesueur made 5 subsequent voyages to New Orleans, but apparently no further collections of fossils. He continued to use New Harmony as his base until after the death of Thomas Say in 1834 and of his friend Barrabino in the same year. Maclure, seeking a less severe climate, had left New Harmony for Jalapa in November, 1828, and died in Mexico. Lesueur was made the Director of the Musée d'Histoire Naturelle of Havre upon his return to France in 1837. His collections, sketches and notes were divided between the museums of Paris and that of Havre. He died in Havre, his birthplace, December 12, 1846, at the age of 68. His life may recall that of Audubon, another roamer from France. The record he has left bears witness to "son crayon si fin et si alerte et sa plume si pesante et si embarrassée."

LOCULIPORA IMPLICATA, NEW NAME FOR LOCULIPORA LOCULATA McNAIR (NOT HALL)

ANDREW H. McNAIR
Dartmouth College, Hanover, New Hampshire

Madeleine A. Fritz has notified me that the name *loculata*, recently proposed by me for a species of the bryozoa genus *Loculipora* (Contr. Mus. Pal., Univ. Mich., Vol. V, No. 9, p. 113, 1937), was used in 1888 by Hall for a species which was later placed in this genus. The new name *Loculipora implicata* McNair, therefore, is proposed for *Loculipora loculata* McNair, not Hall.

SOCIETY RECORDS AND ACTIVITIES

PALEONTOLOGICAL SOCIETY: NOMINEES FOR OFFICE

The Council of the Paleontological Society has nominated the following persons as officers of the Society for 1939:

For President, R. W. CHENEY, Berkeley, California

For Vice-President, A. S. ROMER, Cambridge, Massachusetts

For Secretary, B. F. HOWELL, Cambridge, Massachusetts

For Treasurer, ROBERT R. SHROCK, Cambridge, Massachusetts

For Editor, C. WYTHE COOKE, Washington, D. C.

The next annual meeting of the Society will be held in New York City December 28–30, 1938.

INTERNATIONAL PALEONTOLOGICAL UNION

REPORT ON THE MEETING AT MOSCOW

The International Paleontological Union, in whose organization the Paleontological Society took an active part, held its first regular meeting in Moscow from July 21st to 26th, 1937, in conjunction with the Seventeenth International Geological Congress. The meeting was successful, and the Union is now well launched on a career which it is believed will make it of great service to Paleontology. Twenty-one members of the Council of the Union, representing 31 of the 63 organizations now in the Union, attended the Moscow sessions. The undersigned represented the Paleontological Society.

The following officers were elected for the three-year period ending with the next regular meeting, which will be held in London in the summer of 1940, when the Eighteenth International Geological Congress will convene in that city:

President: PIERRE PRUVOST

Vice-Presidents: A. MORLEY DAVIES, W. J. JONGMANS, A. KRYSHTOFOVICH, and RUDOLF RICHTER

Secretary: B. F. HOWELL

Treasurer: C. E. RESSER

It was voted to set the dues of the Union for the next three years at one dollar per year for each organization in the Union and one dollar per year for each individual wishing to join the Union independently.

The following committees were appointed: a Committee on Nomenclature of Types, with Dr. W. J. JONGMANS as Chairman; a Committee on Cataloging and Distribution of Type Specimens, with Dr. A. KRYSHTOFOVICH as Chairman; and a Committee on Proterozoic Correlation, with Professor B. F. HOWELL as Chairman. Dr. S. H. HAUGHTON, the Chairman of the Geological Congress' Committee on Paleontologia Universalis proposed to the Union that he should ask that his committee be permitted to disband and that a corresponding committee be appointed in its place by the Union. This proposal was approved by the Union and such a committee, with Dr. HAUGHTON as Chairman, was appointed to serve if the proposal was approved by the Council of the Congress.

One of the features of the Moscow meetings was a Symposium on Proterozoic and Paleozoic Climates, sponsored jointly by the Union and the Seventeenth International Geological Congress. The thirty papers presented in this symposium will be published in the Comptes rendus of the Congress.

The constitution and by-laws of the Union are appended.

C. C. Case
C. O. Dunbar
Henry V. Howe
B. F. Howell

CONSTITUTION

I. The International Paleontological Union is established for the purpose of promoting and coordinating international activities in paleontology and stratigraphy. It shall promote these sciences by furnishing an organization that will be capable of caring for international problems, and particularly by providing a ready means by which paleontologists may become acquainted and may learn what work is in progress.

II. The membership of the Union shall include all paleontological societies and other organizations that support paleontology.

Paleontologists and stratigraphers not members of organizations in the Union may be elected members of the Union by the Council.

III. There shall be a Council, which shall direct the activities of the Union. This Council shall be composed of members appointed by each organization in the Union in the proportion of one member for each 100, or fraction thereof, of its paleontological membership. Additional Council members may be elected by the Council from persons not belonging to any organization within the Union.

BY-LAWS

1. The President and Vice-Presidents of the Union shall be elected by a majority vote of the Council. These elections shall be held each year in which the International Geological Congress meets.

2. A secretary shall be elected by a majority vote of the Council to serve until such time as the Council may elect his successor.

The secretary shall be the executive officer of the Union and secretary of the Council.

3. An Executive Committee of three members shall be designated by the Council. This committee shall include the secretary and two other members who can normally be reached by return mail in 20 days.

4. The Council shall meet at each International Geological Congress. For each such meeting 7 members of the Council shall be considered a quorum.

5. Public scientific sessions shall be held in conjunction with each International Geological Congress.

6. These By-Laws may be altered or amended by a two-thirds vote of the Council.

REVIEW

Fenton, Carroll Lane, *Life long ago*, 287 pp., 150 figs., Reynal and Hitchcock, Inc. New York, 1937. Cloth, $3.50.

It is most welcome news when a man who has advanced science by his research contributions publishes along his own line of work a book for younger readers. Too often juvenile books are written by non-scientists and leave much to be desired in the way of truth. The author summarizes in a graphic manner the succession of animal life in earth history. He describes where and how the fossils of plants and animals are found, what they look like, their habitat when alive, their environment and mode of life.

The book is divided into four parts. Part one, consisting of five chapters, tells what fossils are, where to find them, and what they mean, also how they are related in families and larger groups.

Part two describes plants and invertebrate animals that lived in the ancient seas. It includes 23 chapters. Many of the chapter titles in this section show the author's keen appreciation of the dramatic interest that may be found in our reconstruction of the life of the ancient seas. Many of the names that have been given to the fossils suggest their appearance or manner of life. There is a chapter on "Plants that made rocks," on "When sponges were hard," on "Shells shaped like lamps," "Trilobite's kingdom," "Coral horns and honey combs," "Moss animals and tube worms," "Crinoids and 'petrified nuts'," "The ways of 'Ammon's stones'."

Part three presents fishes and the plants, reptiles and birds that lived on land while the continents were rising and changing. Chapter titles that suggest the range of interest and manner of treatment are, "Plants, insects and

coal," "From puddles to land," "On the Texas delta," "The first dinosaurs," "Reptiles that flew," "When birds had teeth."

Part four, in eleven chapters, deals with the era of mammals, ending with a particularly interesting chapter on "Living fossils," and a list of books and museums for further study.

The drawings and photographs are abundant and well done and aid greatly in an understanding of the life of the past. Seven of these illustrations are full-color pages. The publishers have handled this material well and in text, illustration, and binding have made an attractive book.

The author is careful to distinguish between what "we think" and what "we know," and yet nowhere does he forget that his primary purpose is to make fossils a subject of life interest to young readers. His definition, for example, of such a term as adaptation, his definition and illustrative examples of earth revolution, his reducing to essentials of the differences between plants and animals, his imagined trip in diving suit to the bottom of the Cambrian sea, all illustrate this happy combination of scientist and dramatic writer.

HERVEY W. SHIMER